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See advertisement page 19.
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AUTOMATIC FEED REGULATORS.
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OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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See half-page Advert. last week and next week. 2087

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BIRMINGHAM. 1241
See Advertisement last week, page 19.

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PATENT BOILERS *See Page 49.* 1994
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Specification and Workmanship equal to Main Line Locomotives.
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and
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 33, Dec. 5.

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Worm Wheels cut up to 12 ft. diam.
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GENERATING SETS, Totally Enclosed, Three Crank Self-Lubricating Engine, with Complete Condensing Plant, by Allens, Pipes, Valves, Oil Separator, Etc., complete.
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See Advertisement, page 54. 1872

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
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REFRIGERATING PLANT. 1475
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IN WHOLE OR PLOTS.
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High-class GUNMETAL STEAM FITTINGS.
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[LAND AND MARINE
YARROW BOILERS. 2277

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 2212
See Full Page Advt., page 59, Dec. 5.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 80, Dec. 5. 8195

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Three Nearly New Cochran
VERTICAL BOILERS, 14 ft. by 6 ft. 6 in., 100 lbs. w.p. Date 1918. Excellent reports. Low price before removal
400 H.P. Marshall Horizontal Drop Valve Cross Coupled STEAM ENGINE, Cylinder 22½ in. by 36 in. stroke. Also one 250 H.P., Cross Compound Drop Valves.
140/160 H.P. Horizontal Superheated STEAM ENGINE and BOILER by Garrett, Locomobile type rope Flywheels, 170 lbs. w.p.
New 7½ ton ELECTRIC CAPSTAN, by Stothert and Pitt. 220 volts D.C., 41 tons pulling load. Excellent Capstan for shipyard or Dock work.
Two ELECTRIC TURBINE PUMPS, 470 ft. head, 160 gallons per min. 150 ft. head, 300 gallons per min., 440 volts D.C.
Weir Vertical Boiler FEED PUMP, capacity 7,000 gallons per hour, land type.
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Special designs only.
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See advertisement alternate weeks. 9235

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Head of Department:
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The following courses of instruction will be given during the 2nd and 3rd Terms (January to June).
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A course of lectures which will meet the requirements of those engaged in Electro-metallurgical, Chemical and other Industries, and those wishing to prepare for the degree of B.Sc. (Eng.) of London University.
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Lectures and practical work, Friday evenings, 7 to 10 p.m., commencing January 9th, 1925.
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Details of the above courses may be had upon application to the Principal. G 651

Correspondence Courses for

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Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2431

TENDERS.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

ELECTRIFICATION OF BOMBAY SUBURBAN LINE.

The Directors are prepared to receive

Tenders for the Supply of the

following PLANT required for the equipment of manually operated Traction Substations:—
1. SUBSTATION AND TRACK SECTIONING SWITCHGEAR AND ACCESSORIES.
2. ROTARY CONVERTER SETS.
3. TRANSFORMERS.
Alternatively for Automatic Substations:—
4. SUBSTATION EQUIPMENTS AND TRACK SECTIONING SWITCHGEAR.
Fee for Specifications £2 per copy.
Specifications and forms of Tender (which must be submitted in duplicate) may be obtained at this Office on and after December 10th, 1924, on payment of the fee for the Specification, which payment will not be returned.
Contractors may Tender for any or all of the above sections. Tenders must be sealed and addressed to the undersigned, marked "Tender for Substation Switchgear" or as the case may be, and delivered not later than Noon on Tuesday, 24th February, 1925.
The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to The Bombay, Baroda & Central India Railway Company.
The Directors do not bind themselves to accept the lowest or any Tender.
The Consulting Engineers to whom application for any further technical information may be made are Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, S.W.1.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
92, Petty France,
Westminster, S.W.1.
8th December, 1924. G 650

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

45 BOGIE STEEL COVERED GOODS WAGONS.
Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Wagons," must be left with the undersigned not later than Twelve Noon on Friday, the 13th February, 1925.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of £1 for each copy of the Specification.
Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
10th December, 1924. G 670

THE GUARDIANS of the POOR of the PARISH of LAMBETH hereby invite

Tenders for the Provision and

INSTALLATION of an HYDRO EXTRACTOR at their Norwood School
General description of machine required, together with Form of Tender, may be obtained from this Office. Tenders are returnable on or before Tuesday, the 6th January, 1925. The Guardians do not pledge themselves to accept the lowest or any Tender.

By Order.
JAMES L. GOLDSPINK,
Clerk to the Guardians.

Guardians' Offices,
128, Brook Street, Kennington, S.E.11.
11th December, 1924. G 677

THE GUARDIANS of the POOR of the PARISH of LAMBETH hereby invite

Tenders for the Provision and

INSTALLATION of a MULTITUBULAR HEATER at their Lambeth Hospital.
Specifications, together with Form of Tender, may be obtained from this Office. Tenders are returnable on or before Tuesday, the 6th January, 1925. The Guardians do not pledge themselves to accept the lowest or any Tender.

By Order.
JAMES L. GOLDSPINK,
Clerk to the Guardians.

Guardians' Offices,
128, Brook Street, Kennington, S.E.11.
11th December, 1924. G 678

TAF FECHAN WATER SUPPLY BOARD.
TENDERS FOR STEEL PIPES, VALVES, &c.
The Taf Fechan Water Supply Board are prepared to receive

Tenders for the Supply and

DELIVERY at certain railway stations in South Wales of about 5000 tons of STEEL SOCKET and SPIGOT PIPES of diameters ranging from 37 in. to 17 in., together with certain CAST IRON PIPES, VALVES and SPECIALS, all of British material and manufacture. Though lap-welded steel pipes are specified, Tenderers are at liberty to offer other makes of steel pipes, but riveted pipes will not be accepted. Drawings may be seen and Specification and Form of Tender obtained at the offices of Sir ALEX. BINNIE, SON & DEACON, 30, Buckingham Gate, Westminster, S.W.1, on payment of a cheque for £5 made out to the Taf Fechan Water Supply Board, which amount will be returned on receipt of a *bona fide* Tender. Sealed Tenders, endorsed "Tender for Steel Pipes, Valves, &c.," should be delivered at my office at or before Noon on Tuesday, the 23rd day of December, 1924.
The lowest or any Tender will not necessarily be accepted nor will any expenses in connection with Tendering be defrayed. No Tenders will be considered except from actual manufacturers capable of supplying the pipes at the rate of 600 tons per month, together with a proportionate number of valves and specials.

J. COLENSO JONES,
Clerk to the Board.

Board's Offices,
101, High Street,
Merthyr Tydfil.
1st December, 1924. G 556

METROPOLITAN ASYLUMS BOARD.

TO HEATING ENGINEERS.

The Board invite separate

Tenders for

(1) PROVIDING and FIXING HEATING and HOT WATER APPARATUS, COLD WATER MAINS, FIRE HYDRANTS and GAS SERVICES at Tooting Bec Hospital, S.W.17.
(2) PROVIDING and ERECTING a PLENUM HOT AIR HEATING APPARATUS in erecting shop at The Mead Works, Carnwath Road, Fulham, S.W.6.
(3) PROVIDING and FIXING NEW 20-ton WEIGHBRIDGE at the Southern Fever Hospital, Dartford, Kent.

in accordance with the Specifications and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specifications, Drawings, and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after 10 a.m., on Friday, 12 December, 1924, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender, sent in accordance with the instructions on the Form of Tender, and after the Specification and the Drawings have been returned.
Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 31st December, 1924.

G. A. POWELL,
Clerk to the Board. G 642

CITY OF NOTTINGHAM.

The TRAMWAYS COMMITTEE are prepared to receive

Tenders for the Supply and

DELIVERY of 200 tons of STEEL TRAMWAY RAILS.
Copies of the Specification and Form of Tender may be obtained on applying to Mr. T. WALLIS GORDON, City Engineer and Surveyor, Guildhall, Nottingham, on payment of a deposit of One Pound, which will be returned on receipt of a *bona-fide* Tender.
Sealed Tenders in the official envelope provided are to be delivered to the undersigned not later than Six p.m. on Wednesday, 31st December, 1924.
The lowest or any Tender will not necessarily be accepted, and the Committee reserve to themselves the right to divide the order.
Tenders will only be accepted from firms who conform to the conditions of the contract as regard paying the local standard rate of wages, etc.

W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
10th December, 1924. G 667

APPOINTMENTS OPEN

Test Assistant with technical training to the standard of B.Sc. degree and works and drawing office experience REQUIRED at the Royal Aircraft Establishment, in connection with checking by calculation the strength and aerodynamic characteristics of aeroplanes. Starting salary 60s. per week plus Civil Service Bonus, giving a present total of 94s. 11d. p.w. Ex-service man preferred.—Apply, quoting A.42, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. G 638

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

MECHANICAL DEPARTMENT.

Applications are Invited for

an Experienced MECHANICAL ENGINEERING ASSISTANT. Must be a good draughtsman and fully conversant with the design and construction of large pumping units of all types. Applicants having a knowledge of electricity preferred.
Commencing salary £375 per annum, which is subject to deductions under the Company's Superannuation Scheme.
Applications with copies of three recent testimonials should state experience, age and when at liberty, and be addressed to the undersigned, endorsed "Mechanical Assistant."

FRED. J. DIXON, M.Inst.C.E.,
Engineer-in-Chief.

Engineer's Office,
28a, Paradise Street,
Birmingham.
3rd December, 1924. G 618

COUNTY BOROUGH OF WEST HAM.

WEST HAM MUNICIPAL COLLEGE,
Romford Road, Stratford, E.15.

Applications are Invited for

the POST of full-time ASSISTANT TEACHER in the Department of Engineering from candidates with University Degree and works experience. Salary in accordance with the Technical Burnham Scale for the London Area less 5 per cent., and subject to deduction for superannuation. Applicants must be members of a recognised Teachers' Organisation. Forms of application may be obtained from the Principal and should be returned not later than Monday, 5th January, 1925.

GEO. E. HILLBARY,
Town Clerk.

Education Department,
95, The Grove, Stratford, E.15.
3rd December, 1924. G 636

THE MUNICIPALITY OF SINGAPORE.
STRAITS SETTLEMENTS.

CHIEF ASSISTANT GAS ENGINEER.
The Municipal Commissioners of Singapore require a

Chief Assistant Gas Engineer,

age about 30-35, of sound constitution, and unmarried. He must have had a good technical education, a regular training as a Gas Engineer, with general all-round experience, including Carbonising and Water-Gas Plant, both in the design and in the construction of new works and in ordinary maintenance and in distribution.
The appointment will be on agreement for three years with possible extension. The selected candidate must pass a medical examination as to his fitness for service in a tropical climate. A passage will be provided with half-salary during the voyage out.
The salary will be 7440 dollars for the first, 7920 dollars for the second, and 8400 dollars for the third year, paid monthly, the value of the dollar being two shillings and fourpence sterling. For the first year the salary would be equal to £868 as above, with an allowance for such transport as may be required when on duty.
Applications, stating age and place of birth, and giving details of education, training, and experience generally, and in Carbonising Machinery and Water-Gas Plant, and stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. C. C. LINDSAY AND PEIRCE, MM.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Municipal Commissioners (from whom further information may be obtained), not later than Tuesday, 16th December, 1924. G 610

THE MUNICIPALITY OF SINGAPORE.

STRAITS SETTLEMENTS.

WATER ENGINEER.

The Municipal Commissioners of Singapore require a

Water Engineer, Age 35-43,

on a four years' agreement, with possible extension. Candidates must have had considerable experience, in a responsible capacity, of the design and maintenance of important Waterworks, including Impounding Reservoirs, Pumps, Slow Sand and Mechanical Filters, Service Reservoirs, Detection of Waste and the Distribution of Water throughout a large Town. The selected candidate will be required to control the whole of the Water Department and to advise the Commissioners on all matters regarding the water supply of the City, apart from a large new water scheme now in progress under a Westminster firm of Engineers. He must be a Corporate Member of the Institution of Civil Engineers, having responsible experience with a Water Company or the Water Department of a Public Authority. Administrative experience is an essential of this appointment. The population supplied with water is about 350,000 and the whole supply is impounded and pumped. There is a considerable area of open sand filters but the filtration capacity is to be greatly extended, and mechanical filters are under consideration. Two pumping engines, each of about 8½ million gallons per day, are about to be installed, with boilers and auxiliary plant. There is a salt water pumping and distribution system. The total expenditure of the Water Department in 1923 was about £250,000, and the average daily consumption was nearly 11,000,000 gallons of which a large portion is waste and must be reduced.
Salary $12,000 for the first, $13,200 for the second, $14,400 for the third, and $15,600 for the fourth year, paid monthly, in dollars, the currency of the Colony, the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £1,400, rising to a maximum of about £1,900 in five years. Such local transport allowance as may from time to time be sanctioned by the Commissioners, will be paid. Free passage will be provided with half-pay during the voyage out. The selected candidate must pass a medical examination.
Applications, stating whether married or single, age, and place of birth, and giving details of education, training and experience, particularly in Waterworks, and referring to all the above requirements in detail, accompanied by copies (only) of testimonials, to be lodged with Messrs. C. C. LINDSAY & PEIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents for the Commissioners, not later than Tuesday, 23rd December, 1924. G 637

DIRECTOR OF RESEARCH FOR CHILEAN NITRATE INDUSTRY.

The Association of Producers of Nitrate of Soda in Chile intends to organise a Central Research Department in that country.

A Director of Research,

Salary £30 0 per annum, and TWO SUB-DIRECTORS, salaries £2500 each, per annum, are REQUIRED.
The appointments will be for three years in the first instance.
Chemists, or Chemical Engineers, with first-class scientific training and successful experience in the scientific investigation, design, and operation of large scale processes and plant are wanted for these posts.
Applicants should be if possible, between 35 and 45 years of age. No previous knowledge of Spanish is required. For further particulars, apply to:—

THE SECRETARY,
THE CHILEAN NITRATE COMMITTEE,
Friars House, G 550
New Broad Street, London, E.C.2.

Test Assistant Required for the Aerodynamics Experimental Department of the ROYAL AIRCRAFT ESTABLISHMENT. Technical training to the standard of a degree in natural science or engineering is essential, and candidates must be willing and medically fit to fly as observers. Other things being equal, preference will be given to ex-service men. Starting salary about 60s. per week plus cost of living bonus, giving a present total of about 95s.—Apply, giving full particulars and quoting A. 43, to the SUPERINTENDENT, R.A.E., South Farnborough, Hants. G 676

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THE EFFECT OF SLIGHT TAPER ON SHEAR IN A GIRDER.

By Professor L. N. G. FILON, F.R.S., University College, London.

PROFESSOR C. E. INGLIS has shown, in a paper published some time ago ("Some Special Cases of Two Dimensional Stress or Strain," Trans. Inst. Naval Architects, vol. lxiv, 1922), how to obtain the distribution of stress in a flat tapering cantilever, bent in its own plane under a given bending moment and transverse force applied at the vertex. His formulæ are expressed in polar co-ordinates, the vertex of the tapering piece being the pole, but he gives some diagrams showing the distribution of shear and normal stress across a plane cross-section in special cases.

It so happens that, in the case of *small* taper, Inglis's formulæ can be shown to lead to singularly simple approximations, especially in the case of the distribution of shear across a section, and, although the deduction of the results is quite straightforward, it may not be without interest to give them explicitly. Moreover, it may not be unnecessary to call attention to the fact that, although Inglis's formulæ have been established for a cantilever tapering uniformly to a point, the application of de Saint-Venant's well-known principle of equipollent loads shows that they do in fact provide a close approximation to the stress distribution in any part of a flat girder in which there is a uniform taper and which is free from loads, quite independently of the shape, extent, or state of loading of the other portions of the girder, provided only that the length of the uniformly tapering part is large compared with its height.

Using the notation of Love's "Elasticity," it is easy to show that Inglis's solution for a tapering cantilever whose edges converge to a vertex at O (Fig. 1), and subject per unit thickness to a transverse force F through O and a couple M_0, the edges A B, A′ B′ being unstressed, is deducible from a stress function χ, given by

$$\chi = \frac{M_0(\sin\theta\cos\theta - \theta\cos 2\alpha)}{2\alpha\cos 2\alpha - \sin 2\alpha} + \frac{F r\theta\cos\theta}{2\alpha - \sin 2\alpha} \quad (1)$$

2α being the angle of taper, and r, θ being polar co-ordinates referred to O as pole, the initial line OX being the axis of symmetry of the tapering piece.

It is easy to verify that this expression for χ leads, on differentiation, to the expressions for the mean stresses in polar co-ordinates given by Inglis, on applying the standard formulæ

$$\widehat{rr} = \frac{1}{r^2}\frac{\partial^2\chi}{\partial\theta^2} + \frac{1}{r}\frac{\partial\chi}{\partial r},\quad \widehat{r\theta} = -\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial\chi}{\partial\theta}\right),$$
$$\widehat{\theta\theta} = \frac{\partial^2\chi}{dr^2} \quad . \quad . \quad . \quad . \quad (2)$$

the notation being that of Love's "Elasticity" (3rd edition).

If, however, we write the above expression for χ in rectangular co-ordinates x, y referred to O as origin and OX as axis of x, we have

$$\chi = \frac{M_0\{xy/(x^2+y^2) - \cos 2\alpha\tan^{-1}(y/x)\}}{2\alpha\cos 2\alpha - \sin 2\alpha} + \frac{F x\tan^{-1}(y/x)}{2\alpha - \sin 2\alpha} \quad . \quad . \quad . \quad (3)$$

Applying now the formulæ for the mean stresses in rectangular co-ordinates, we obtain, by direct differentiation,

$$\widehat{xx} = \frac{\partial^2\chi}{\partial y^2} = \frac{2M_0 xy\{(x^2+y^2)\cos 2\alpha - 3x^2 + y^2\}}{(2\alpha\cos 2\alpha - \sin 2\alpha)(x^2+y^2)^3} - \frac{2Fx^2y}{(2\alpha - \sin 2\alpha)(x^2+y^2)^2} \quad . \quad . \quad (4)$$

$$\widehat{xy} = -\frac{\partial^2\chi}{\partial x\,\partial y} = \frac{M_0\{(x^4-y^4)\cos 2\alpha - x^4 - y^4 + 6x^2y^2\}}{(2\alpha\cos 2\alpha - \sin 2\alpha)(x^2+y^2)^3} + \frac{2Fxy^2}{(2\alpha - \sin 2\alpha)(x^2+y^2)^2} \quad . \quad . \quad (5)$$

$$\widehat{yy} = \frac{\partial^2\chi}{\partial x^2} = \frac{2M_0 xy\{x^2 - 3y^2 - (x^2+y^2)\cos 2\alpha\}}{(2\alpha\cos 2\alpha - \sin 2\alpha)(x^2+y^2)^3} - \frac{2Fy^3}{(2\alpha - \sin 2\alpha)(x^2+y^2)^2} \quad . \quad . \quad (6)$$

Consider a cross-section (PP′ in Fig. 1) of breadth $2b$, so that we write $x = b\cot\alpha$, and develop the results in ascending powers of α, or $\tan\alpha$, which is supposed small, neglecting all terms which involve higher powers of $\tan\alpha$ than the first, when multiplied by M_0, or than the zeroth when multiplied by F. This amounts, as will be seen, to retaining only the first approximation in each case, except in that of $\widehat{yy}$, where this approximation is of the same order as the terms neglected in the other cases.

The results then take the form

$$\left.\begin{aligned}\widehat{xx} &= \frac{3y}{2b^3}(M_0 - Fb\cot\alpha)\\ \widehat{xy} &= \frac{3}{4}\frac{M_0\tan\alpha}{b^4}(3y^2 - b^2) - \frac{3}{2}\frac{Fy^2}{b^3}\\ \widehat{yy} &= 0\end{aligned}\right\} \quad (7)$$

If now S and M denote the total shear and bending moment at the cross section PP′, then, t being the thickness of the girder, we have clearly

$$F = -S/t;\quad M_0 = -M/t - Sb\cot\alpha/t \quad . \quad (8)$$

Substituting these values into (7) we obtain the

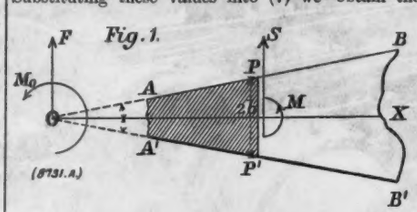


Fig. 1.

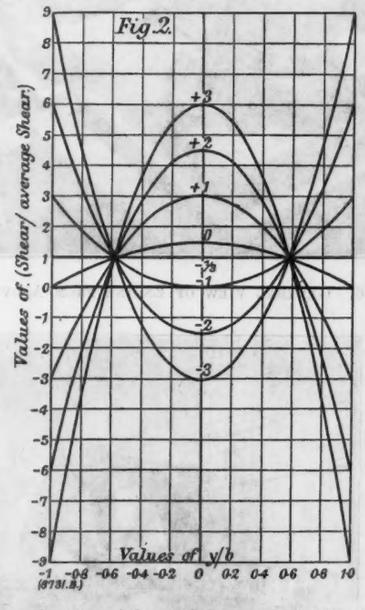


Fig. 2.

stresses in terms of the total shear and total bending moment at the cross section considered, in the form

$$\widehat{xx} = -\frac{3yM}{2b^3t} = -My/I \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\widehat{xy} = \frac{3S}{4b^3t}(b^2 - y^2) - \frac{3}{4}\frac{M\tan\alpha}{b^4t}(3y^2 - b^2) \quad . \quad (10)$$

$$\widehat{yy} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

I denoting the moment of inertia of the cross section about the neutral axis, as usual.

(9) shows that, to this approximation, the distribution of normal stress is the same as that given by the usual theory of flexure of straight beams, but (10) shows a very remarkable variation in the distribution of shear, provided (as very frequently occurs in practice) that the bending moment is sufficiently large to make $(M\tan\alpha)/b$ comparable with S.

The shear distribution is always parabolic, but upon the usual de Saint-Venant parabola (given by the term in S) assumed in ordinary engineering practice, we have superposed another parabola, of different shape, depending only on the bending moment, and the resultant shear distribution is the sum of the two.

The following special cases are worth noting:—

(i) At a point of inflexion M = 0 and the de Saint-Venant distribution of shear is unaffected by taper.

(ii) If $M = -Sb\cot\alpha$, that is, the single force statically equivalent to the load on the left of PP′ passes through the point of convergence of the tapering edges, then

$$\widehat{xy} = \frac{3}{2}\frac{Sy^2}{b^3t} \quad . \quad . \quad . \quad . \quad (12)$$

and the shear is actually zero at the centre and a maximum at the edges.

(iii) If $M = -\frac{1}{3}Sb\cot\alpha$, that is, the "effective" load acts at one-third of the distance to the point of convergence (this corresponds to the case of a uniformly tapering cantilever extending to the vertex and bent under its own weight), then

$$\widehat{xy} = S/2\,b\,t$$

or we have a *uniform distribution of shear* over the cross section.

(iv) If the "effective" load is at a distance very great compared with that of the point of convergence, $M\tan\alpha$ may be large compared with S. We then have in the limit the case of a tapering piece under a constant bending moment (*e.g.*, a girder simply supported, with symmetrical over-hanging loads). In such a case there is a shear

$$-\frac{3}{4}\frac{M\tan\alpha}{b^4t}(3y^2 - b^2)$$

across the section, which is entirely due to the taper.

Fig. 2 shows the various distributions of shear over the section, expressed in terms of the mean shear as unit, as the ratio $(M\tan\alpha)/bS$ varies from -3 to $+3$. The curves all pass through the points $y = \pm b/\sqrt{3}$, shear/mean shear $= 1$. The values of $(M\tan\alpha)/bS$ are shown against the corresponding curves.

At first sight it appears surprising that the maximum shear should, in so many cases, occur at the edges, where the shear ought, presumably, to vanish. A little consideration, however, shows that, if the taper be taken into account, the stress conditions at the boundary no longer require that $\widehat{xy} = \widehat{yy} = 0$, the correct conditions, say, over the edge $y = +b$, being

$$\widehat{xy} = \widehat{xx}\tan\alpha,\quad \widehat{yy} = \widehat{xy}\tan\alpha,$$

and the first of these obviously gives (since $y = +b$)

$$\widehat{xy} = +(Mb\tan\alpha)/I = -3(M\tan\alpha)/2b^2t,$$

which agrees with the value given by (10) for the shear at that edge.

The above results show that taper, even slight, may seriously disturb the de Saint-Venant parabolic distribution of shear over a section, although the Euler-Bernouilli formula for the normal stress remains a good approximation. Formula (10) however, provides a simple and easily applied correction to the shear over any region in which there exists uniform taper.

THE PENANG HILLS RAILWAY.

(*Continued from page* 730).

HAVING dealt with the constructional features of the railway, the permanent way and the rolling-stock, we may now pass to a description of the winding engines or hoists, which are of very considerable interest. They are of the Whiting type and are among the first of such gears of anything like similar dimensions to be manufactured in this country. Their construction, and installation without any hitch, reflects great credit on Messrs. Robey and Co., Limited, of Globe Works, Lincoln, who supplied them. As we have already stated, and as will be clear from our general description of the operation of the railway, there are two winding engines, one at the summit and one at the middle of the railway. Each operates one section of the line, the haulage rope for each section being attached to the two cars and led from one car to the other over the drums of the engine. The two engines are practically identical and in our description it will facilitate explanation if we refer to one only.

Two views of one of the engines are given in Figs. 66 and 67 on page 790, while general arrangement drawings are given in Figs. 68 to 70 on page 791. Drum details are shown in Figs. 71 to 76 on page 792, and further views showing one of the engines erected in Messrs. Robey's works are given

HAULAGE ENGINE FOR THE PENANG HILLS RAILWAY.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

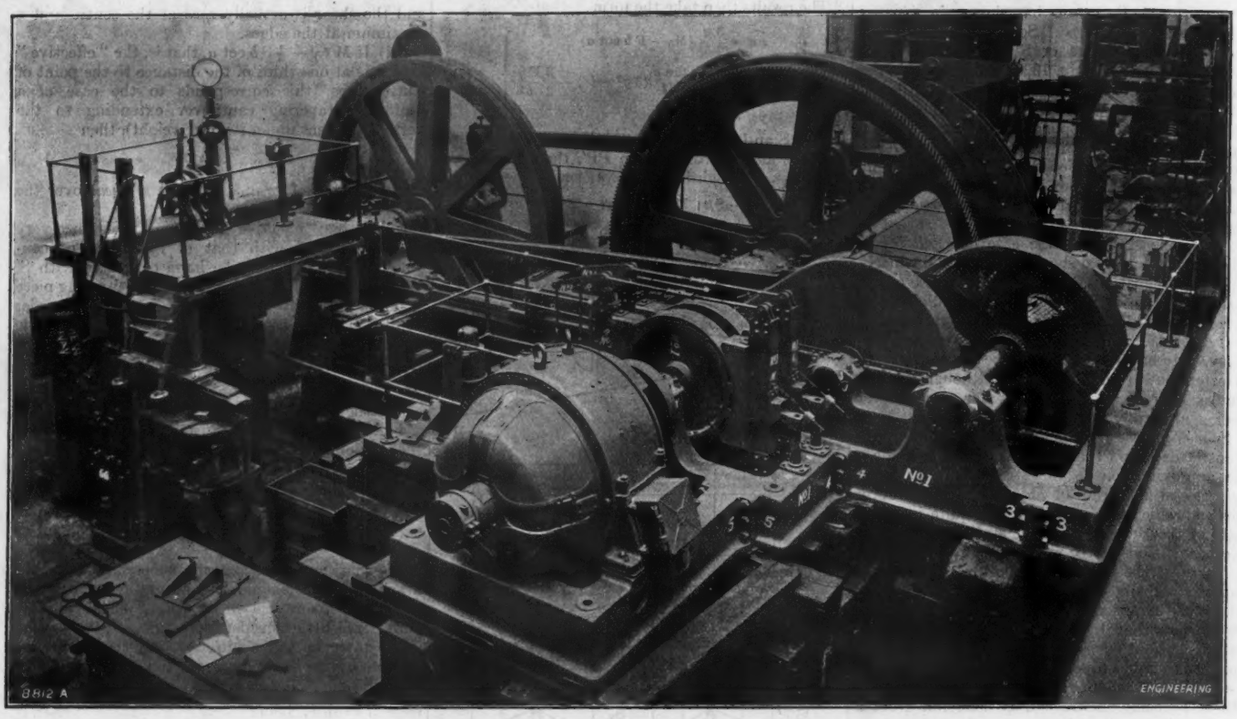


Fig. 66. General View of Engine from Above.

in Figs. 77 and 78 on page 804. The arrangement of the haulage will best be followed from Figs. 68 to 70. It consists of two driving drums, or sheaves, each machined to carry three Walker differential rings to receive the rope. The drums are mounted on separate shafts, one in front of and below the other, and are driven in unison by means of cranks and coupling rods. It will be noted that in Figs. 66 and 67 annexed and also in Figs. 77 and 78 on page 804, that the two shafts are mounted at the same level. This, however, is merely a temporary arrangement adopted for convenience during erection in the makers' works. The shafts on site are mounted as shown in Figs. 68 and 69. As will be seen from these figures, the lower drum, or counter-sheave, is mounted so that it runs at an angle to the main sheave. The purpose of this arrangement is to ensure that the on-coming and off-going ropes passing from one sheave to the other lead truly in and out of the grooves. As will be gathered from the figures the upper rope (Fig. 68) leads direct to the main sheave, makes two complete turns around the two sheaves and on the third turn leaves the counter-sheave at a point near the bottom and passes over a guide pulley to the railway track.

The main sheave is carried on a steel shaft 11 in. in diameter and the counter sheave on a steel shaft 10 in. in diameter. All the shafts are carried in spherical seated bearings, fitted with ring lubrication. The sheaves are 12 ft. 6 in. in diameter. The main bearing housings, as well as all bearings of the driving gear, are cast solid with the bedplate to ensure rigid construction. As will be seen from Fig. 70, the main drum is driven through triple-reduction gears from a 75 brake horse-power electric motor driving through a flexible coupling. The motor runs at 500 r.p.m. and the gearing reduces the speed of the driving sheave to 6·5 r.p.m. for the haulage of the lower section, and 8 r.p.m. for the haulage of the upper section. As we have already pointed out, a higher speed of the cars is adopted from the upper section, as it is the longer of the two and the two sections, of course, operate

Fig. 67. The Main and Counter-Sheaves.

in conjunction. The first reduction is by means of a machine cut straight tooth raw-hide pinion and mild steel spur wheel, and the second and third reductions are by means of cast-steel machine cut double-helical wheels.

The details of the main drums, or sheaves, will be followed from Figs. 71 to 76. They are made of cast-steel and constructed in halves. The main sheave, which is shown in Figs. 71 and 72, is provided with a cast-steel brake path and a gear ring, on opposite sides, and bolted to the flanges. They are centralised by means of turned spigots on the sheave. The machined rim of the sheave is formed with one fixed flange, and a clamping ring is bolted on the opposite side, a rubber packing ring being placed between the ring and the face of the spigot. The arrangement of the Walker differential rings will be followed from Figs. 73 to 75. There are five rings, three with rope grooves and two intermediate plain rings. They are an easy fit on the rim of the wheel, so that they are capable of independent circumferential adjustment, while the friction between them may be adjusted by means of the loose flange ring and the rubber

HAULAGE ENGINE FOR THE PENANG HILLS RAILWAY.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

Fig. 68.

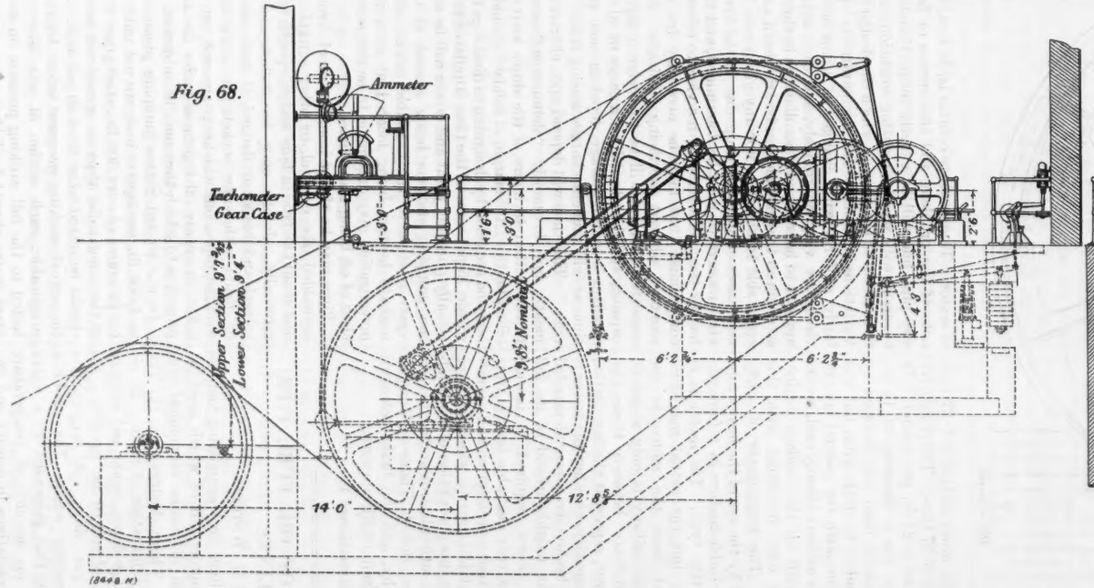


Fig. 69.

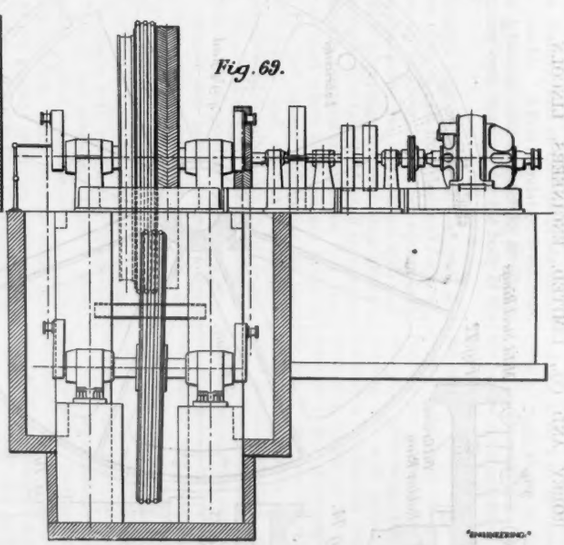
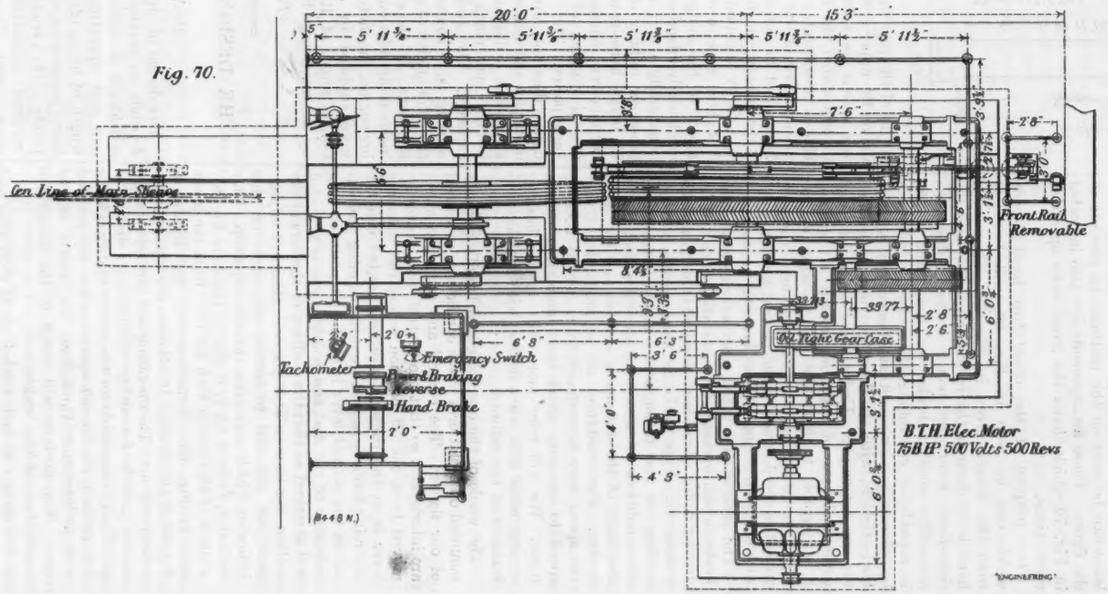


Fig. 70.



packing ring. The object of this arrangement is to prevent unequal stresses in the rope due to wear in the treads. If such wear is not compensated for, it might cause very great and unforeseen stresses in the rope, as a very small difference in diameter may mean an appreciable difference in tread length in a drum of this size. With the arrangement adopted, if the drum wears down at one side any effect of slackening one turn of the rope, and the throwing of undue stress on other turns, is compensated for by slight automatic and individual adjustment of the separate rings.

The gear is fitted with an emergency brake operating on the main brake drum. It consists of a pair of heavy post brakes of the curved floating type carried at the horizontal centre line of the sheave on approximately vertical struts hinged at the lower end. The brake is operated by a weight of 650 lb., normally held in the off position by a locking bolt held up against a small weight by an electrically energised solenoid. The falling of this weight throws the brake on. The arrangement of the brake with the falling weight and linkage gear will be clear from Fig. 68. The brake is so designed that when the weight is released the braking effect is sufficient to bring the main sheave to rest when the rope has travelled through a distance of 10 ft., and when the gear is running at 20 per cent. above normal haulage speed. The brake is tripped under any of the following contingencies: (*a*) when the speed of the sheave

exceeds 15 per cent. of the normal winding speed; (*b*) when the ascending car reaches a predetermined position at the top of the section; (*c*) when current fails either through the tripping of the main circuit-breaker owing to overload, or to interruption of supply; (*d*) when an emergency switch on the central platform is operated by hand. The brake operates owing to the opening of the main circuit breaker cutting off current from the solenoid. The various conditions of operation which we have quoted are provided for by an overspeed device on the motor, an overwind switch on the track, and an emergency hand-operated switch on the driver's platform.

The winding engine is also provided with an automatic electric brake which operates on a brake drum mounted on the motor pinion shaft. It is operated by means of a weight normally held in the off position by an electric solenoid, and is applied immediately the main controller is on its first rheostatic braking contact. This brake is designed to hold a static load 10 per cent. in excess of the maximum possible static load on the haulage gear. A similar brake, but hand-operated, is provided alongside this automatic electric brake. The two brake drums and brakes can clearly be seen in Fig. 66. The hand brake is the one in front in the illustration, and its operating hand lever can be seen on the platform to the left of the figure. These arrangements are also indicated in Fig. 70 which shows the hand-brake operating connections.

The purpose of the other two hand levers, which can be seen in Fig. 66, will be clear from the details given in Fig. 70. The centre hand lever controls the reverse controller, and the right-hand lever the power brake. Either the automatic electric brake or the hand brake is capable of controlling the gear throughout a complete trip under conditions of maximum negative load—that is, with the down car fully loaded and the up car empty. Under these conditions, and without the use of any other means of braking, it is possible to hold the load in any position throughout the trip, and to perform a complete trip at a speed equal to the normal hauling speed without overheating at the braking surfaces.

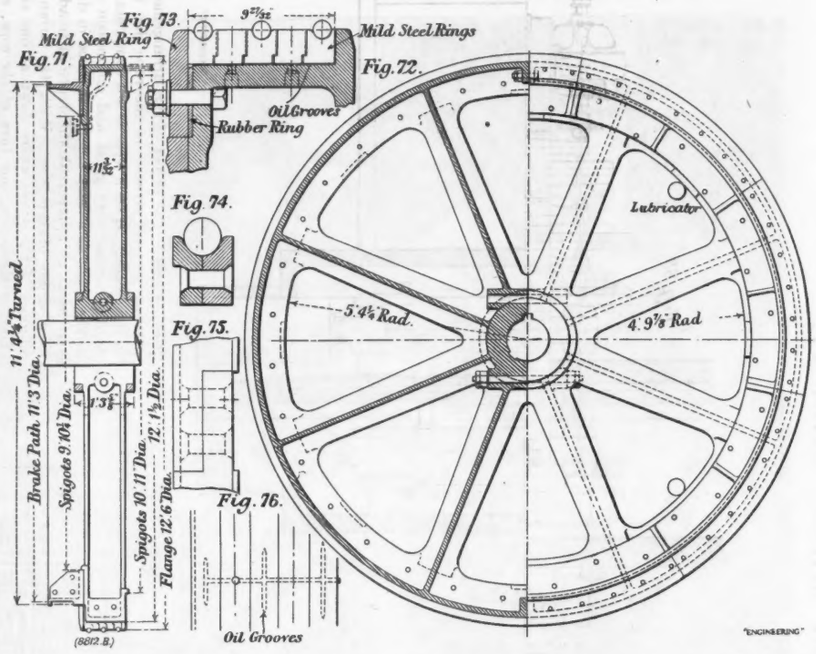
The gear is also fitted with an electrical hand brake, which operates by rheostatic control of the driving motor when short-circuited through variable resistances. This brake is also capable of controlling the gear throughout a complete trip under the conditions of maximum negative load, as in the cases of the automatic electric and the hand brakes. The resistances are so proportioned that the speed may be reduced from normal winding speed to creeping speed for examination of the ropes. We will refer more fully to the braking arrangements later when dealing with the electrical features of the railway.

The whole of the operating and handling gear is mounted on a platform which can be seen in several of our figures. The control and reversing levers are interlocked, so that the control lever cannot be moved from the off position unless the reversing lever is in the running position, neither can the reversing lever be moved from the running position unless the control lever is in the off position. An indicator of the dial and pointer type is provided and arranged so that the position of the cars in the section can be seen at a glance. Means of adjustment are provided to correct any error on this indicator which may arise through rope slip. This indicator, in back view, is clearly visible in Fig. 67, while it is also shown with its drive from the lower axle in Fig. 68. A tachometer, well shown in Fig. 66, is also fitted. It indicates the rope speed in miles per hour. The operating and control arrangements provide for every contingency, and it is practically impossible for the driver to do anything but perform the correct operation for any position and circumstance throughout the travel of the cars. Any mistake will result in the immediate application of the brakes.

The weight of each loaded car is 9·35 tons and each loaded goods wagon 3·44 tons, the empty car weighing 5·9 tons and the empty goods wagon 1·5 tons. The length of rope on the lower section is 2,954 ft., and on the upper section 3,622 ft. The

ROPE WHEELS; PENANG HILLS RAILWAY.

MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.



weight of the rope on the lower section is 5·37 tons and on the upper section 6·57 tons. The respective rope speeds are 4·28 and 5·25 ft. per second. As already stated the rope has a diameter of 1¼ in. This is considerably heavier than was dictated by consideration of the load to be dealt with, but was determined in connection with the general lay-out of the railway, which, as we have already said, results in a fairly constant load on the haulage engine. A lighter rope would have interfered with this aspect of the design. The large factor of safety incidentally introduced by the use of the heavy rope is naturally a very desirable feature in a funicular passenger railway of this type. The motor is of 75 brake horse-power, but the actual maximum horse-power demanded from the motor in the normal working of the railway is only about 36 horse-power. The difference between these two figures does not, however, represent the installation of surplus and useless capacity, as, when the motor is utilized as a dynamo brake, the power demanded from it may reach the neighbourhood of its full capacity. The small power required in normal working is, of course, a very desirable feature from the point of view of current consumption and operating costs. Of the electrical gear to which we have incidentally referred in this description of the winding engine, the motors, switchboards and controllers were supplied by the British Thomson-Houston Co., Limited, of Rugby, and the brake solenoids by Messrs. George Ellison, of Birmingham.

(*To be continued.*)

THE DESIGN OF OIL FUEL PIPE LINES.

By W. G. WATKINS.

THE design of pipe lines for transmitting fuel oils depends on several factors, all of which must be considered in order to determine economical lay-out and operating. These factors are (1) The length of line; (2) configuration of route; (3) relative positions of storage depot, intake and delivery points; (4) varieties of oil to be handled; (5) required quantities per day; (6) construction costs; and (7) operating costs. The problem generally is similar to that presented by a water main, but modified on account of temperature changes which cause variations in density and viscosity of oil to a far greater extent than in the case of water. Temperature control is, in fact, the keynote of the problem, and the success or failure of any pipe line will be exactly proportionate to the accuracy with which operating conditions are made to conform to the data on which the design is based. Variations in density are, comparatively speaking, fairly uniform with changes of temperature, but viscosities vary enormously, and each type of oil appears to have its own peculiarities in this respect, so much so that no rule can be laid down as equally applicable to all oils. For any given case the friction losses or pressure drop due to the five factors first enumerated must be determined, and the other factors then considered with a view to effecting any compromise that may be necessary for ultimate economy without sacrificing efficiency. In many cases the problem will be to design a pipe line of capacity sufficient to deliver a cargo of oil from the "tanker" to the storage depot in such period of time as will prevent charges arising from "demurrage." This time will depend upon charter arrangements, but frequently "demurrage" commences to run within 48 hours of the ship's arrival at the oiling berth. A "margin of safety" should accordingly be provided by designing to discharge the cargo within 75 per cent. of the time stipulated in charter. Usually pumping plant and power will be necessary, the pumping stations being spaced at distances apart relative to the available power, and intermediate heaters being located at such points as investigation may determine to be necessary for the class of oil being transmitted.

Pipes may be of cast iron, cast steel, wrought and lapwelded iron or steel, or other suitable material and should be true in bore and as smooth as possible internally. Joints may be socket and spigot; turned and bored or flanged, if cast, and flanged or made with screw sockets or screw collars for wrought pipes, but whichever are used, care must be taken to ensure oil tightness under the maximum pressures to which they may be subjected.

In the United States pumping pressures of 800 to 1,000 lb. per square inch are not unknown, and for pressures of over 300 lb., steel pipes with joints of the screw collar type are considered best. Pipes should be tested to at least 50 per cent. more than the actual working pressure before laying, and, if practicable, each section of pipe line should be tested to the full working pressure on completion. Steel mains should be laid in comparatively wide trenches, and provision made for contraction by

leading the pipe from side to side of the trench in zigzag fashion. The filling around pipe should be so composed and laid as to offer as little resistance as possible to the free movement of the pipe line under temperature changes, and all definite bends should be as free as possible. A firm foundation is essential and the trench bottom must be carefully levelled or graded to ensure even bearings for the body of the pipe.

In this country high pressures are unusual and pipe lines are often of cast iron, designed for working pressures up to about 300 lb. per square inch. Spigot and socket joints, run and caulked with lead, present certain advantages in that they afford a means in themselves, of taking up small movements due to moderate temperature changes, but they should not be used where pressures are likely to exceed 200 lbs. per square inch owing to their tendency to "draw," and, contrary to the practice with steel pipes, all definite bends should be provided with thrust blocks to prevent movement at these points as far as possible. Cast-iron pipes laid above ground are better flanged, suitable expansion joints being provided at intervals, and the pipes supported on roller bearings. Temperature stresses in the pipe in excess of the elastic limit of the material must be avoided. Flanged joints may be made with very highly compressed asbestos millboard, not exceeding $\frac{1}{16}$ in. in thickness, completely coated with Fenner's or similar petrol-resisting solution. Care must be taken that the coating is not cracked or broken while making the joint. Corrugated iron or steel rings coated with a metallic cement may also be used, but are somewhat expensive. The narrow type, fitting inside the bolt circle, is both cheaper and more effective than the full size rings. To prevent corrosion between the flanges the spaces may be caulked with metallic cement or lead. Sheet lead may also be used but is liable to deformation in handling, and is expensive. Jointing rings must not protrude into the interior of the pipe, and care must be taken when bolting up, to ensure even pressures all round. It is advisable to put the bolts in alternately from right and left hand to eliminate any tendency to twist the pipe when screwing up nuts.

Pipe lines of lap-welded steel have many advantages over those of cast iron, being lighter and tougher. They have fewer joints and can be put together in long lengths at the side of the trench and lowered into position, reducing the actual jointing in trenches to a minimum. Special bends are also largely avoided, as pipes can in many cases be bent on the job with care in manipulation, and lines can be laid in a fraction of the time required for laying and jointing cast-iron pipes. The disadvantage of a steel pipe is its greater liability to corrosion, but this may be largely obviated by coating with Dr. Angus Smith's solution while hot, followed by wrapping with rot-proofed roofing paper, which again is coated with the solution. A pipe made of rustless steel would be a great asset if obtainable at moderate cost, and if possessing the flexibility of mild steel. The attention of manufacturers is invited to the possibility of the production of such pipes.

Where extremely viscous oils, such as Mexican or Trinidad, have to be dealt with in large quantities the provision of heat-insulating pipe coverings is very desirable, but the question of cost must be carefully considered. Except in cases where oils of the nature named form the bulk of the quantity handled, the cost of coverings cannot usually be justified. To reduce viscosity generally and consequently the pumping power required, it is usual to employ some form of heater. Each pumping station should be provided with heating apparatus, utilising the exhaust steam from pumps, and, where stations are far apart, intermediate heaters should be installed. Station heaters comprising closed steel cylinders fitted internally with headers and tubes through which the oil makes two or more passes on its way from the receiver to the pumps are as efficient and economical as any. The exhaust steam from the pumps is made to pass between the headers and tubes and the oil is quickly raised to any required initial temperature, usually from 100 deg. F. to 150 deg. F., while passing through the apparatus.

Intermediate heaters are placed at such position along the pipe line as are indicated by an investigation of the temperature—distance—history of the particular oil or oils dealt with. A convenient arrangement is a bye-pass manifold of small pipes, not less than 3 in. or more than 6 in. in diameter, lying at right angles to the main line, carried in a brick or concrete flue, through which are drawn the heated gases generated by an oil-burning furnace at one end. This flue should be of such length that the oil travels some 300 to 500 ft. through the small pipes while being heated. The oil main itself supplies the necessary fuel for the furnace, a suitable reducing valve being fitted on the branch for the purpose, and with proper air control a practically smokeless combustion can be obtained with an atomizing burner of the usual type, and the temperature of the oil may be raised from 25 deg. F. to 50 deg. F. at these intermediate points. By careful investigation on these lines the cost of one or more pumping stations on long pipe lines may be saved. The importance of reducing viscosity and maintaining equable temperatures wherever possible can hardly be over estimated, as the working costs rise rapidly with increasing viscosity. Pipe lines should be placed underground at such depth as will ensure being unaffected by climatic changes as far as this is compatible with ready access for repairs or alterations, &c.

Where practicable, oil pipe lines, of whatever type, should be in duplicate, to guard against the possibility of a breakdown. These duplicate lines should be so arranged as to permit of use either jointly or singly, as may be required, in either direction. The sizes of duplicate mains should be such that their combined areas is equal to at least one and a-half times that required for a single pipe line discharging a given quantity per hour. It must be borne in mind that the friction losses increase rapidly as the diameter of the pipe decreases, and a double pipe line may necessitate increased pumping power. Approximate relative figures are as follows :—

Diameter of Pipe. In.	Relative Frictional Resistance.
16	1·0
14	1·31
12	1·77
10	2·56
8	4·0
6	7.1

From the foregoing it is clear that the friction losses increase approximately in inverse ratio to the square of the diameter of the pipe, other things being equal.

The valves used must be of the very best materials, and the highest quality of workmanship to ensure absolute oil tightness under the pressures put upon them.

The body should be of the highest grade of cast iron or steel, and all wearing parts must be of gunmetal. The type will vary somewhat with size, but for mains of 6 in. to 16 in. diameter clear way, the split-gate sluice valve as made by any of the firms specialising in valves for oil services will be found satisfactory. For the higher pressures special modifications of design may be necessary, as such valves are not normally designed for pressures much in excess of 400 lb. per square inch. So far as possible, valves on pumping mains should be few and far between, and located in such positions as will ensure proper control. Reflux and by-pass valves may be introduced with advantage near the foot of abrupt or steep rises, though these should, wherever possible, be avoided, the aim being to maintain even grades between pumping stations even if it is impossible to do so throughout.

Relief valves may be required near the delivery point. These should be of simple construction and, once set, must be certain to come into action when required, even if receiving only a minimum of attention.

Air valves may be necessary in very undulating country, but so far as possible dips or bumps in pipe lines should be avoided, every endeavour being made to lay the line at even gradients between the pumping stations.

The filters must be of ample size in order that flow may not be impeded. Wire gauze is the usual filtering medium, and care must be taken that the total area through the meshes is such that no additional pressure is exerted on the fittings. They should be at least in duplicate to facilitate cleaning and to avoid stoppage of pumping.

The choice of pumps for any particular installation requires careful consideration, and depends upon the work to be done, whether continuous or intermittent; the nature of oil pumped and the average temperature conditions in the pipe line. The design must be exceptionally strong and the proportions such that for each pound of steam pressure at the boilers an effective pumping pressure of 6 lb. to 8 lb. per square inch may be realised. Steam pumps in general use in American pipe lines are usually either of the crank and flywheel type or the direct-acting duplex plunger type. The former are more economical in general running, but are not so well adapted for starting the oil in a long pipe line after a shut down as the direct-acting type.

It is desirable that a period of rest, especially in cold weather or with oils of high viscosity, should be avoided, every effort being made, once the oil is in motion, to keep it moving. It is also advisable, where long periods of rest are likely to occur, to provide for emptying each section of the pipe line, either by gravity at a convenient point or by compressed air. In either case a storage tank or reservoir of sufficient capacity to hold the contents of the section should be provided. This should preferably be in close proximity to a pumping station, and arrangements should be made for heating the oil before allowing it to again enter the pipe line on resuming pumping operations. Some oils, partioularly the more viscous varieties, such as Mexican or creosote, if allowed to remain dormant for any length of time are exceedingly difficult to start moving again, and long periods of rest with these oils result in the encrustation of the pipes with a deposit of a substance not unlike paraffin wax, which is very hard to remove except under prolonged application of heat. For this reason when pumping has to be stopped the complete emptying of the pipe line should be effected wherever possible.

Motor-driven pumps may also be used where power is available. Hand-power pumps are so limited in action that they need not be considered as of practical use so far as pipe lines are concerned, but are useful for handling small quantities of oil for charging ready use tanks or reservoirs for fuel supply to boilers, &c., when power is not available.

At the risk of being tedious, the importance of avoiding large variations in temperature must be emphasised. It has been found that in California the capacity of a pipe line in the summer is no less than seven times its winter capacity. In America 8 in. diameter pipe lines at 800 lb. pressure are common, and are usually reckoned to have a capacity equal to from 20,000 to 30,000 barrels per day normally.

A 6-in. line is usually worked at a higher pressure, and its capacity is normally 10,000 to 16,000 barrels per day (1 barrel equals 35 English gallons, approximately).

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the Institution of Mechanical Engineers was held on Friday last, the 5th inst. at the Institution Building, Storey's Gate, Westminster, the President, Mr. W. H. Patchell, occupying the chair.

PROPERTIES OF MATERIALS.

There were two papers submitted to the meeting for discussion, and both dealt with the behaviour of materials under physical tests. The first was entitled : "The Effect of Low and High Temperatures on Materials," and was prepared by Professor F. C. Lea, D.Sc. A summary of this paper was first presented by the author. The second paper bore the title "The Elastic Limit in Tension, and its Influence on the Breakdown by Fatigue," and was the work of Mr. J. M. Lessells, B.Sc., of the Westinghouse Research Laboratory, East Pittsburg, Pa., U.S.A. In the absence of the author, Professor B. P. Haigh introduced the paper with a few remarks explanatory of its contents and aim. Both

papers are reprinted in abstract in another part of the present issue (see pages 816 and 813).

The President, in opening the discussion on the two papers, which were considered together, observed that he had touched upon the subject of Professor Lea's paper in the Presidential Address he recently delivered to the Institution, as he felt that, in this direction, work was urgently needed. He also referred to the fact that one of the first Committees formed to consider the strength of materials at high temperatures was in being in 1836 and made its report in 1837. That Committee had regarded the prospect of getting materials to stand very high temperatures as hopeless.

Mr. H. J. Tapsel, of the National Physical Laboratory, was specially interested in Professor Lea's paper, as he (the speaker) had paid great attention to the subject of creep in the course of his high temperature work at the Laboratory. He was surprised to find that Professor Lea had remarked that he was not aware that any other worker had dealt with the subject. A paper had been read by Mr. J. H. S. Dickenson, before the Iron and Steel Institute in 1922, and was entitled "Some Experiments on the Flow of Steel at Low Red Heat," which bore upon the subject, while Professor Chevenard, in France, had dealt with the matter in the "*Comptes Rendus*" in 1920 and 1922 and elsewhere. One or two American investigators had also tackled the problem. In testing valve steels at the National Physical Laboratory up to very high temperatures, the rate of loading was found to be an important factor, and further tests on various materials, conducted in 1921, showed the importance of rate of loading. Creep tests were then carried out and some interesting facts obtained. The National Physical Laboratory were now working on the subject for the Engineering Research Board, as could be seen in the programme in the Annual Report of the Laboratory for 1923. The programme covered tensile, creep, torsion and fatigue tests, and impact and hardness investigations.

In the paper, were given the results of tests of comparatively short duration, of a few days or even a few hours, and certain curves were shown. The speaker had made a number of tests which lasted much longer. To some extent he disagreed from the views of the author on the form of the curves. His own curves showed that the creep did not necessarily become constant within a few hours or a few days; the creep only tended to show a constant rate after, perhaps, several weeks. In one test, in which a failure occurred in 79 days, the creep did not attain an approximately steady rate until 30 days after commencement of the test. In another case, when the test piece was left for 142 days, the creep had not even then attained a truly constant rate, although the elongation had reached 11 per cent. on the test piece. Early in his paper, Professor Lea remarked of his tests that the technique used in connection with them was novel, but in Professor Chevenard's papers it would be seen that the method he used was the same as that of Professor Lea. The straight lines of Professor Lea's graphs were really fictitious; they would not be straight if the tests were continued long enough and the graphs would be found to be curved at first, then to continue almost straight for a long time and then to show a further curve. This action was typical. If Professor Lea intended to take the slope of the curve where the stress became more or less steady, he must conduct long period tests. In the case of the 142 days test the speaker had mentioned, the stress was never constant. At the National Physical Laboratory the procedure was to explore thoroughly the behaviour of the creep over long-extended intervals on one or two materials, not short-time tests on a number of materials. From the tests made they had been able to estimate loads in the same way as Professor Lea, which, put on the test piece, would not cause fracture although allowed to remain on for a considerable length of time and at any given temperature. This load, divided by the original cross section, they called the limiting creep stress of the material.

It was stated that in one test the author was able to control the temperature by $\pm$ 5 deg. Without any particular control of the heating, the furnaces used by the speaker were subject to $\pm$ 10 deg., but he had managed to find a simple device to control the temperature to $\pm$ 2 deg. The greatest variation, in the early morning in his case, was when the battery began to run down. During the night, when most of the load was put on the battery, a variation of 10 deg., such as might have been obtained by Professor Lea, would, in some cases, with specific load and temperature, cause an increase in the rate of creep of from 5 to 10 times. He was inclined to think that the variation in rate of creep shown in the figures in the paper might be due to alteration in the furnace temperature. It was necessary to keep the variations of temperature very small. Towards the close of the paper Professor Lea said that tests were required on the effect of low temperature on impact. At the National Physical Laboratory several series of impact tests had been made on steels at low temperature, and the results had been contributed to the Aeronautical Research Committee.

A curve was given by Professor Lea which showed the fatigue ranges at various temperatures, and he asked Professor Lea if the figures used for that curve were those given in the paper. Did the author consider that there was sufficient information given in the tables with which to draw the curve? At the National Physical Laboratory it was considered absolutely necessary when doing fatigue tests to run at least one test at a stress just below the fatigue range, in order to check the range estimated. He had run one test for 10 or 12 million reversals, in order to make sure that the estimated fatigue range obtained was correct.

Mr. Tapsel then asked Professor Lea whether when referring to "energy of blow" he meant energy absorbed by the material. Professor Lea had said in this connection that the "height of rebound" could be observed, but did not say that the observation had been utilised in any way. Further, on the subject of hardness tests, the author had frequently referred to the area of indentation, but the speaker could not find any suggestion of whether the projected area of indentation was considered. He asked if Professor Lea had any experience of furnaces with nickel chrome alloy tubes. These furnaces could be worked at higher temperatures than the others, and had no tendency to buckle.

Sir Henry Fowler, referring to the question of the effect of shock on material subjected to low temperature, expressed himself as glad to hear that information on that most important point was in existence, and hoped that before long it would be made available to engineers. Great as the interest of the papers had been, he felt distressed to think that with high temperatures it was necessary to work with such a comparatively small load. In asking for information on shock, he was aware that he was asking too much. He was somewhat doubtful whether engineers were not being too richly fed on these subjects. When attending the meetings of the British Association, he had been invited to go and see a tremendous series of tests being carried out. Dr. Haigh had put forward, for Mr. Lessells, a point in relation to fatigue. It was to be understood that if the elastic and yield-points were close together the fatigue range could be increased. Did he mean, at the same time, that the duration of the fatigue test and the millions of repetition stresses which were required could be increased? The speaker also remarked that Mr. Tapsel had referred to a 79-days test, and also to one of 142 days. He shuddered to think of having to wait for the production of locomotives until the material could be got through, if such figures had to be included in the specification.

Professor H. P. Philpot emphasised one point made by Professor Lea, but not dealt with in the paper by Mr. Lessells. Professor Lea had pointed out the importance of starting with material in a known condition of heat-treatment for the tests. The speaker believed that a great amount of the difficulty experienced in understanding the results of such tests arose from the fact that so many tests were made on material in an unknown condition. Mr. Lessells, in his paper, had observed, under the heading "Internal Stress," that all previous remarks referred only to materials of a similar structure and did not include heat-treated materials. He wanted to know what were the materials of similar structure which were not heat-treated. Materials which were of similar structure surely needed to be brought to that similarity by some sort of heat-treatment before the tests were commenced. Mr. Lessells practically excluded any heat-treated material from his view. The speaker would therefore feel doubtful about accepting any of the conclusions drawn in the paper, based apparently on material in unknown conditions in regard to structure.

Mr. H. Gough, of the National Physical Laboratory, said that Mr. Lessells' paper dealt with the most complicated problems of repeated stresses; the extent to which primitive elasticity contributed to fatigue breakdown. Apparently, the object of the paper was to show that the effect of these primitive conditions was very large, and yet could be easily expressed by a simple formula. If, at the same time, it could be established that the formula was correct, he felt that the author had conferred a real boon upon engineers. On the other hand, should the formula at any time prove to be wrong, a great risk to engineers was involved; there would be a tendency to take a simple formula and attempt to work out all sorts of unjustified deductions. The relationship between the various factors, as expressed by Mr. Lessells, meant that the endurance limits in a material in two states was directly proportional to the ratio of their ultimate strengths and elastic limits and inversely proportional to the yield stresses. From that it was obvious that if a material in two states preserved largely unchanged the ratio of yield stresses to elastic limit, it did not matter what the yield stress was or what the elastic limit was, so long as the ratio was the same. The safe range with Armco iron under reverse stresses exceeded the range of the static yield stresses by 100 per cent., the actual value being $\pm$ 12·6 tons per square inch. The limit of proportionality agreed very closely with the yield stress. Taking a piece of that steel—practically pure iron, 0·2 carbon—and loading it in a tensile machine to a stress of 15 tons per square inch, it was found that this was also the yield stress; there would be no limit of proportionality. According to Mr. Lessells' formula, that should have had a tremendous effect on the fatigue rate. It had no effect at all; the fatigue limit was still $\pm$ 12·6 tons per square inch.

Referring to the paper, it would be found that the materials on which Mr. Lessells based his formula consisted of one material in the rolled, the annealed and the normalised condition. If the material had been taken through a critical point it had certainly been heat-treated, so that the author was in the extraordinary position of basing a formula upon heat-treated material, and then stating that it did not apply to heat-treated material. An air-hardened nickel-chrome steel in the fully hardened state, after tempering to different temperatures, showed the following results:—

Condition.	Tensile Elastic Limit.	Yield Stress.	Ultimate Tensile.	Endurance Limit.	Ratio: Endurance Ult. Tensile
Fully hardened ..	15·4	—	113·2	$\pm$43·5	0·39
200° C.	51·6	—	106·0	$\pm$46·5	0·44
400° C.	58·6	—	83·7	$\pm$33·8	0·40
600° C.	30·8	47·7	59·1	$\pm$30·8	0·52

Mr. Lessells' formula could not strictly be applied to this test. In three cases there was no yield point. On the other hand, academically speaking, the yield point could be set close to the ultimate strength. Applying the formula and using the tensile properties of the fully tempered material, the calculated endurance limits for the other states were:—

—	Calculated Value.	Experimental Value.	Error (per Cent.)
Fully hardened ..	$\pm$12·3	$\pm$43·5	−72
200° C.	$\pm$41·3	$\pm$46·5	−11
400° C.	$\pm$47·0	$\pm$33·8	+39

If, on the other other hand, the endurance limits

of these materials were calculated assuming a constant value of endurance ÷ ultimate tensile, the maximum error was 25 per cent. Considering the case of a cold-worked material, after normalising the calculated value of the strained material, using Mr. Lessells' formula, was ± 10·8 tons per square inch, and the experimental value of the endurance limit was ± 13·8, exactly as for the unstrained material. If the specimen were put into an impact tester, the tester would show that something was wrong with the steel. The speaker pointed out that although the fatigue properties of any steel were very important, yet anyone designing a machine to fatigue properties was asking for trouble, as shock-resisting properties, not brought out in a tensile test, had to be considered.

It was important to engineers to discuss the real effect of plastic strain on the fatigue range. To illustrate this point, the speaker exhibited on the screen a view showing the influence of plastic strain on the micro-structure of Armco iron. A large amount of slip was noticeable. Deformation was not, however, observed on every crystal. The specimen had been subjected to 40 million reversals of stress. The microstructure of the same iron was shown when tested to 250 million reversals. If a specimen were tested by a large number of repetitions over the range of stress and were removed from the repeated stress machine and broken in tension, the ultimate strength would be found to have increased. Definite corroboration of that had been obtained from the laboratories at Illinois. With the Brinell test it would be found that the hardness number had gone up. The first effect of slip, therefore, was to strengthen the material. Examination of the slide showed that while some areas were much deformed others were free from any change. The speaker believed that Mr. Lessells' contention that plastic deformation under a range of stress was going to have the effect of reducing the fatigue range, was entirely wrong. He wondered if it was generally recognised that the employment of high working stresses was only possible as a consequence of the strengthening effects of slip. Whatever precautions were taken in design, surface effects, scratches, and discontinuities of surface occurred. If materials of construction were really elastic the effect of discontinuities, &c., would be considerable. What actually happened was that with slip the material became locally strain hardened and a safer redistribution of stress was set up. He maintained, therefore, that at the present time slip was one of the best friends of the engineer. Mr. Gough then went on to refer to the results obtained by Professor Bairstow, which were published in the "Proceedings of the Royal Society," in 1910. Professor Bairstow had agreed that from an engineer's point of view fatigue strength was controlled to a much greater degree by the ultimate tensile strength than by the primitive elastic properties. Speaking on the subject of the deflection method referred to in the paper, he said that in discussing strain methods it should be remembered that the system was originated by Dr. J. H. Smith, of Belfast. At the National Physical Laboratory they had investigated the method and had happened to evolve a method by which Dr. Smith's system could be applied to the Wöhler test. He agreed with Mr. Lessells that the deflection method had limitations.

Professor B. P. Haigh observed that what was lacking in Mr. Lessells' paper was fully made up in the paper by Professor Lea; the two presented different points of view of the same problem. He felt that it would be commonly accepted that the most important part of Mr. Lessells' paper, from the standpoint of practical men, was that relating to the deflection method of finding the fatigue limit. If that method could be relied upon to give the fatigue limit in 30 minutes or an hour, the fear expressed by Sir Henry Fowler would be dispelled, and the test would be invaluable. Meantime, decision must be reserved on the question of reliability, as there was reason to doubt whether it would always give the same result as a long-continued fatigue test. Supposing the fatigue test to be determinable by one method or another, what value was to be placed on the results? Whatever expectations they might have had some years ago, small hope must now be left that the fatigue test alone really gave a measure of the relative safety and strength of different materials subject, say, to alternating stress. In motor cars for instance, the interchangeable parts, having the same fatigue limit in tension and the same ultimate strength, showed different endurances in practice. Mr. Lessells had suggested that account should be taken of the yield point and elastic limit. The speaker had followed up that point during the past few years. The stress calculated by a simple formula, or determined by optical methods as developed by Professor Coker, required qualification before they were compared with the fatigue limit. The qualification was still uncertain, but it had been shown that different metals varied very widely in the ratio that must be allowed as a factor of safety. In metals of ductility a low factor of safety sufficed; without ductility a much higher factor was required. The fatigue limit alone was not sufficient as was demonstrated by actual test under good conditions. The factor of safety could easily vary in a 2 to 1 ratio in metals likely to be used under fatigue conditions. For this uncertain factor it was advisable to look to "creep," which Professor Lea had brought to the attention of members. Creep might occur not only under static stresses, and accelerated by the action of rise of temperature, but at ordinary temperatures under alternating stresses. In a British Association paper published by the speaker about 18 months ago, it was shown that two metals might have almost the same ultimate tensile strength, fatigue limit, yield point and elastic limit, but might differ enormously in creep. It was also there shown that these metals might differ in the Izod shock test figures. He did not know of any two tests which agreed so well in their conclusions as the Izod test and the hysteresis tests which he had been carrying out at the Naval College at Greenwich. So far as he had gone, he had found that when a metal had a low Izod value it had a low primary hysteresis, and in practice an uncertain and short life. A high Izod figure appeared desirable not only where there was a real chance of shock, but also under conditions where shock would not occur but where there was a danger of fatigue.

Professor Lea agreed with Mr. Gough that the optical method of obtaining the fatigue limit was open to criticism, although for a normalised mild steel in good condition he thought that the method did indicate fairly accurately the fatigue limits for equal plus and minus stresses. Equal plus and minus stresses in fatigue work were not, he considered, of the greatest importance to engineers. He then proceeded to reply to the discussion so far as it concerned his paper. Dealing, first, with Mr. Tapsel's remarks, he felt that some of the work done by Mr. Tapsel had been better done than the work carried out at the Universities, where the conditions were difficult. With regard to one of Mr. Tapsel's criticisms, the speaker feared that he had not expressed himself as he had intended. He had used the word "phenomenon" in connection with creep, and added that he did not think the point had been referred to before. He had meant the phenomenon fitting a particular stress at a particular temperature; that was the phenomenon which the test obviously referred to. He was still not sure that this phenomenon had been referred to elsewhere. Fairbairn had carried out investigations on the creep of girders in the 'forties of last century, and Lord Kelvin had also frequently referred to it. Scientific literature for the last fifty or sixty years showed many references to the idea of creep. At a particular temperature, however, there was a particular stress above or below which there would be continuous creep or not continuous creep. He trusted that he had not misled anyone.

With regard to Mr. Tapsel's reference to the graphs, some of the curves produced in the speaker's experiments showed a very similar shape, indicating that the creep increased markedly in rate after a certain number of days. In his paper there was given the history of a piece of material over 34 days. Possibly he had been led astray by the fact that between 15 and 25 days the rate of creep was nearly constant. Afterwards, as Mr. Tapsel had suggested, the rate increased very rapidly. That, however, did not quite touch the point of the paper. He felt that the technique used did give the temperature viscosity stress with considerable accuracy; the method might be arbitrary, but it seemed to work. If the stress at which the material was loaded at a particular temperature was above the temperature viscosity stress, the creep would be fairly constant for a considerable time, and, as shown in the paper, would then increase very rapidly. He also admitted that much additional work was required before any finality could be reached. He had taken stresses below the values given in the table, and had worked specimens for a long time and found that they had not really crept any further. As stated in the paper, an apparatus had been designed which it was hoped would render the ordinary testing machines unnecessary. A number were made, so that specimens might be kept loaded, it was hoped, for a long time.

On the question of temperature referred to by Mr. Tapsel, it was stated in the summary of the paper that when working in the neighbourhood of certain temperatures, change of temperature was far more important than change of stress. The factor of safety was the matter to think about. A change of temperature of 25 per cent. was far more serious than a change of stress of 25 per cent., or even 50 per cent. and in some cases of even 100 per cent. A point he wanted to bring out was this, that at far greater ranges of stress than those which caused continuous creep, the material could be subjected to many millions of repetitions. He agreed with Mr. Tapsel that it was necessary to run for, at least, 10 millions, a point he had been emphasising for a number of years. At less than 10 millions he believed that the fatigue range would not be obtained. The figures given in the paper were given to show that it was possible to run at an extraordinary range of stresses above the creep stress, and with a very large number of repetitions, without the material failing. He was inclined to think there was no real fatigue range above a certain temperature, but he could not, on that occasion, submit his reasons. Fracture did, apparently, occur when working long enough above a particular temperature, and he was not at all sure, in connection with Mr. Gough's figures, whether a specimen at 700 deg. C. or 800 deg. C. could be run with as many as 500 million repetitions without fracture. With regard to the energy given in the blows, this, he thought, was really the energy of the hammer. The "rebounds" obtained above certain temperatures were found to be rather small. He was quite sure that the "energy" given in the paper as the actual energy of blow was estimated by the height of fall of a given mass.

The President terminated the proceedings by calling for votes of thanks to the authors of the papers and to Professor Haigh, and made announcements of the forthcoming meetings.

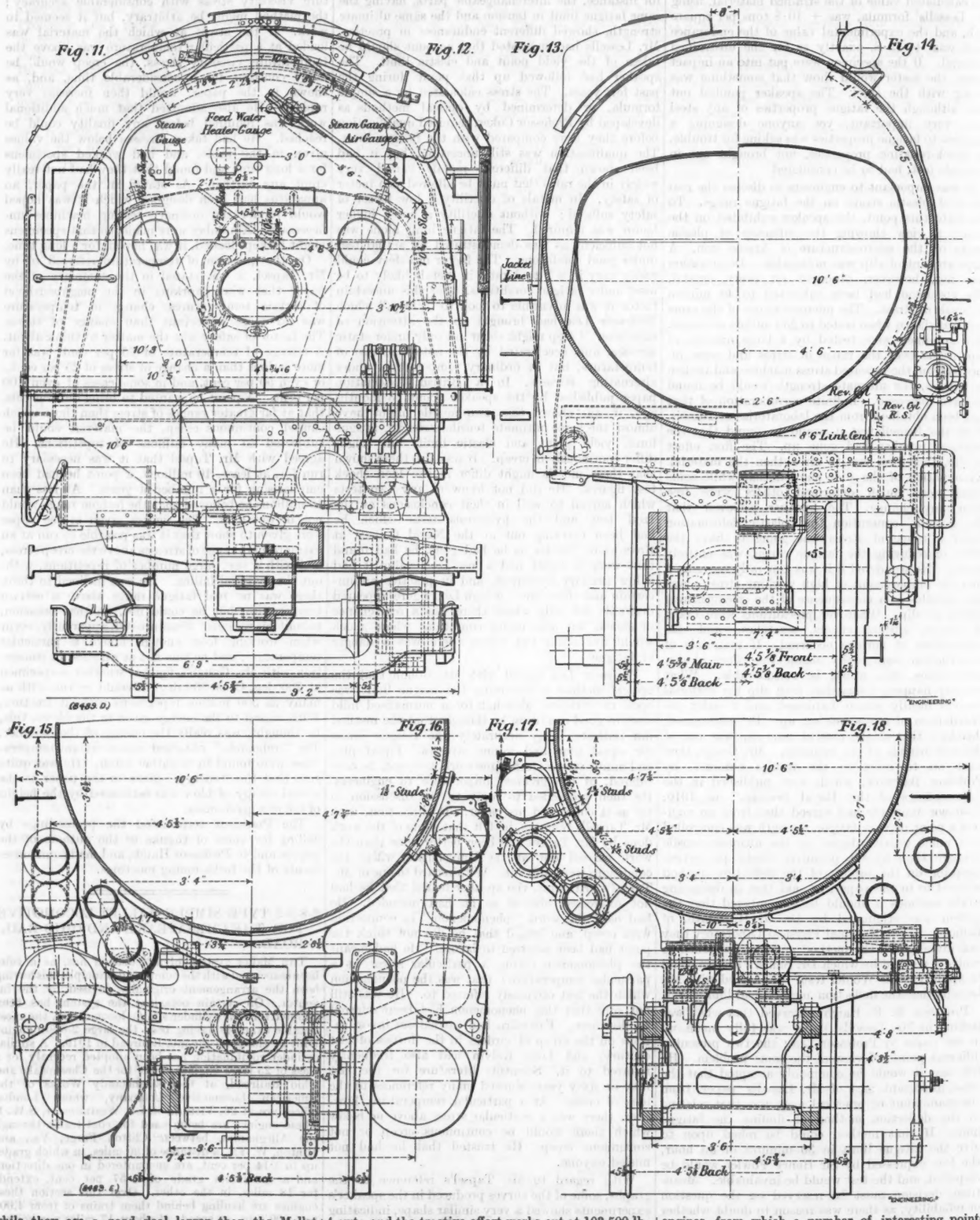
2-8-8-2 TYPE SIMPLE MALLET LOCOMOTIVE FOR THE CHESAPEAKE AND OHIO RAILROAD.

THE Mallet system of articulation has, as a rule, been associated with the compound principle, this having been the arrangement originally devised by the inventor. On certain occasions the system has been adopted for four cylinder simple locomotives, the most notable example having been the large 2-8-8-0 engine built by the Pennsylvania Railroad in 1919. A similar cylinder combination has been adopted recently for a class of 25 large engines, built for the Chesapeake and Ohio Railroad, at the Schenectady Works of the American Locomotive Company, whose London offices are at 26, Victoria-street, Westminster, S.W. 1. These engines are being used for coal traffic through the Alleghanies, between Clifton Forge, Va., and Hinton, W. Va., a distance of 80 miles, in which grades up to 1·14 per cent. are encountered in one direction, and a maximum grade of 0·57 per cent. extends for 18 miles, in the other. Over this section these engines are hauling behind them trains of from 4,000 to 5,000 tons, at speeds of about 17 miles per hour.

The engines are not the largest Mallets in use, nor are they even as large as the Pennsylvania locomotive just referred to, but they constitute a departure in that it is the first time a large class of high pressure engines of this type has been built for road service,

SIMPLE ARTICULATED LOCOMOTIVE; CHESAPEAKE AND OHIO RAILROAD.

CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY, ENGINEERS, SCHENECTADY, N.Y., U.S.A.



while they are a good deal larger than the Mallet compounds previously used by the C. and O. Railroad, and a great deal more powerful. With four cylinders 23 in. in diameter by 32 in. stroke, and a boiler pressure of 205 lb. they can develop no less than 3,902 h.p. The weight on the driving wheels is 219 tons 4 cwt., and the tractive effort works out at 103,500 lb., the total weight of the engine being 252 tons 4·5 cwt., and plus tender in working order, 346 tons 1·5 cwt.

We are able in our two-page Plate LXXXI with this week's issue of ENGINEERING, and above and on the opposite page, to give illustrations of these unusual engines, from which a number of interesting points emerge. The general view given in Fig. 1, Plate LXXXI, conveys an idea of the great length involved in such machines. The total wheel base (engine and tender) works out at 97 ft. 9½ in., the greatest of any locomotive so far built. At the

SIMPLE ARTICULATED LOCOMOTIVE: CHESAPEAKE AND OHIO RAILROAD.

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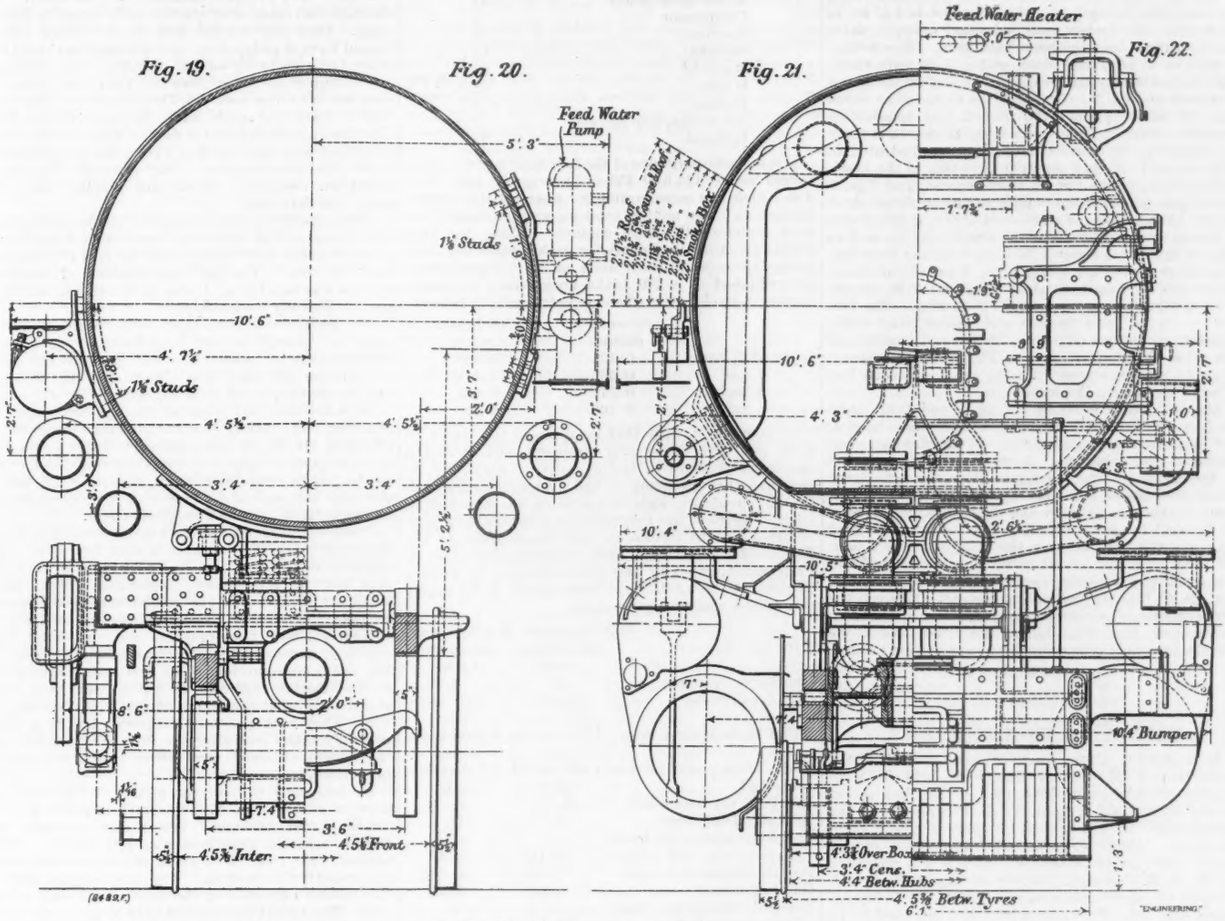
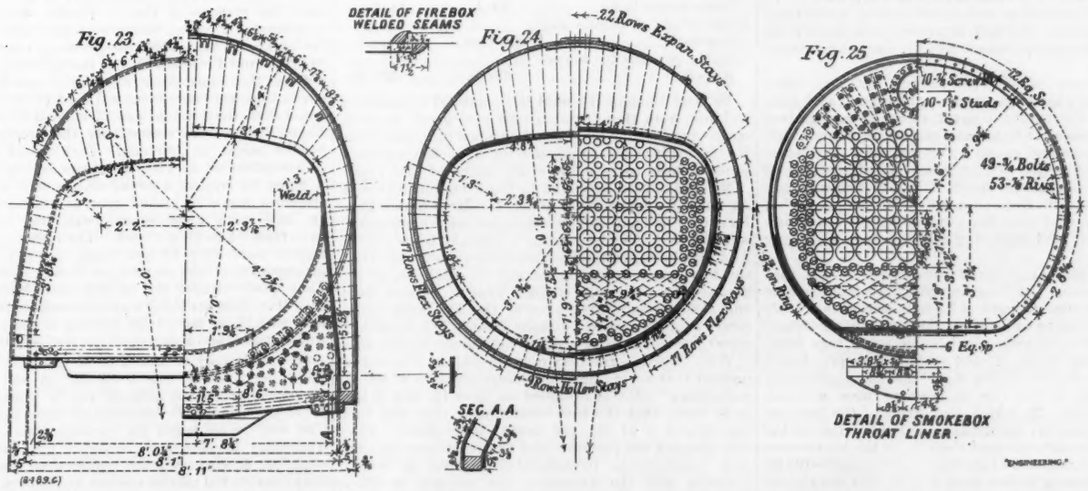




same time an idea is gathered of the boiler dimensions. The top of the chimney is 15 ft. above the rail level, and the boiler, centred at 10 ft. above the rail level, is so large as to permit of the use of a steam dome no more than 5½ in. high, although this is not situated on the largest diameter. The general elevation, Fig. 2, we shall refer to immediately, and leaving for the moment the drawings in Figs. 3 to 10, relating to the boiler, we may state that Fig. 11, page 796, gives a half elevation of the rear end of the engine, Fig. 12 being a half section taken through the cab. In Figs. 13 and 14 are given, respectively, a half section just ahead of the throat sheet looking to the rear, and one looking towards the front. These are taken at the second axle of the rear group of driving wheels. The next half sections, Figs. 15 and 16, are taken just ahead of the back pair of cylinders, and at the trailing drivers of the front group. Figs. 17 and 18 are half sections between the trailing and main drivers of the front group, looking backwards and forwards. Fig. 19, above, is taken at the leading driving wheels, looking to the rear and Fig. 20 slightly further ahead, looking to the front. The series is completed by Figs. 21 and 22, the former being a half section through the smoke box and the latter a half front end elevation.

Figs. 23 to 25, on this page, again refer to the boiler; we propose illustrating further features of this engine in a subsequent issue.

The steaming capacity of the locomotive may be imagined from a consideration of the boiler dimensions The fire-box has a length of 18 ft. at the foundation ring, and a width of 8 ft. 11 in., giving room for a grate measuring 14 ft. by 8 ft. 0¼ in., in front of which is a section separated from the grate by a Gaines arch. The grate area, being reckoned at 112·29 sq. ft., is the largest, we believe, in use. Ahead of the firebox there is a combustion chamber (Fig. 3), while the length between tube plates is no less than 24 ft. The largest

ring of the boiler barrel, *i.e.*, that ahead of the throat sheet, is 104 in. (8 ft. 8 in.) in outside diameter. The barrel tapers towards the front end, where it is 93⅞ in. in diameter, the main reduction being by means of a taper course just ahead of the dome. The thickness of the barrel plates is 1/16 in. for the two front rings, the next two being 1 in., while the last is 1 1/16 in. in thickness. The firebox shell, sides and wrapper plates are ⅞ in. thick, and the back head ⅝ in. The firebox is built up of ⅞-in. steel plate, with a 1⅛-in. tube sheet. The firebox seams are welded as shown in the detail attached to Fig. 24. This applies to the side seams and the seams joining the firebox and combustion chamber, at which latter connection allowance is made for expansion by means of a corrugation illustrated in Figs. 6 and 7. Fig. 8 shows the riveting of the longitudinal seam in the largest barrel course, and Figs. 9 and 10 give details of the outside and inside throat sheet joints. The firebox, as mentioned above, is fitted with a Gaines arch, the position of which may be seen in Fig. 2; this is set about 3 ft. back from the front leg. The water spaces are large, being 6 in. at the front, where the leg is a very short one, and 5 in. at the sides and back, measured at the mud ring. The firebox is stayed with flexible and hollow stay bolts. The boiler contains 60 tubes, 5½ in. in diameter and 278 tubes 2¼ in. in diameter. The sixty superheater elements provide surface of 1,885 sq. ft. The fire box is fed by means of a Duplex stoker.

The bar frames of both the main and front units are 5 in. thick. The boiler is fixed to the main frames, and supported by a stretcher at the fire-box, and saddle at the cylinders. A stay plate is also fitted at the back of the fire-box. Over the articulated frame the barrel receives support in three places. One of these is between the first and second pairs of drivers, the next between the second and third pair, and the third between the third and fourth pair. All these allow for lateral movement, and in addition the front one provides spring support as shown in Fig. 19, to take up vertical movement. Between the two supports is a centring arrangement, spring controlled (see Fig. 18). Liners are fitted inside the barrel where the castings for these supports are located.

(To be continued.)

MARINE OIL-ENGINE TRIALS.

At a meeting of the North-Western Branch of the Institution of Mechanical Engineers, held in Manchester, on Thursday, December 4, the first report of the Marine Oil Engine Trials Committee of the Institutions of Mechanical Engineers and Naval Architects, which we reprinted in abstract in our issues of November 28 and December 5, was presented by Mr. S. B. Freeman. Before the discussion, which followed the presentation of the report, Mr. Dempster Smith said that Mr. Charles Day had intended to be present at the meeting, but, unfortunately, he had had to go to Glasgow. He had, however, contributed some written observations, which he (Mr. Dempster Smith) would read.

In the course of his observations, Mr. Day, after congratulating the Committee on the report, said that, referring to Fig. 20 of the paper, it was to be regretted that the series of tests for any given torque was made over such a limited range. For instance, the test at full speed was limited to full torque. With land engines which ran at a constant speed, it was, of course, necessary to take tests from zero up to full torque at full speed. Had that been done in the present case, comparisons with land engines could have been very fully made.

The indicator diagrams of the Report showed that the fuel settings had been intentionally made to give a rise of pressure during combustion, and in test A.15, that rise was given as from 461 lb. to 606 lb. per square inch. A rise of pressure such as that was very beneficial from the point of view of fuel economy, but it meant that all parts of the engine must be made much heavier than if the rise of pressure were avoided. The curve, Fig. 23, which was given of the fuel per brake horse-power, hardly appeared to be fair to the engine as the curve showed 0·45 lb. as the lowest consumption, whereas one of the tests showed only 0·425 lb. It was interesting to note from Fig. 25 that the highest M.E.P. obtained was 98 lb. per square inch. The highest mechanical efficiency shown was 78 per cent., whereas on page 72 an efficiency of 79·8 was given.

From Fig. 28 it appeared that the compressor absorbed about 7 per cent. of the total i.h.p., but it must not be overlooked that a large proportion of that was returned owing to the compressed air passing to the main cylinders. The outlet temperature of the cooling water at full load was about 128 deg. F. That high temperature was favourable from the point of view of fuel consumption, but was liable to cause deposits in water jackets with many waters.

The interest of the thermal balance-sheet, Table XIX. would be increased if the figures were, in addition, expressed as percentages. The percentages for test A.15 worked out approximately as follows:—

	Per cent.	
Brake horse-power	31	
Compressor	2	
Friction	5	
Jackets	11	38 per cent.
Manifold	10	
Heads	12	
Pistons	3	
Air compressor jackets	2	
Exhaust	24	

The fuel consumptions of the four trials at full torque ranged from 0·425 to 0·455 and averaged 0·445. That was a high fuel consumption for a large 4-stroke cycle engine, and was not as good as was obtained from even quite small Diesel engines. Taking the best results given in the Report for each torque and comparing those with the results of an independently-observed test of a 200 brake horse-power 4-cylinder engine—4-stroke cycle, the comparison was as follows:

	Sycamore engine.	200 b.h.p. engine.
Full load	0·425	0·408
¾-load	0·469	0·416
½-load	0·517	0·466
¼-load	0·708	0·56

In connection with that comparison, he ought to point out that the engine compared with it had a maximum pressure in the cylinder of quite 100 lb. less than that occurring in the Sycamore engine, and that the circulating-water temperature was considerably lower. Again, it was interesting to compare the results obtained on the Sycamore with those given in the *Engineer* for February 3, 1922, in reference to a test by Professor A. Rosborg and representatives of Lloyd's Register of the 1,600 brake horse-power Nobel engine now on the motor-ship Zoroaster.

	M/S Sycamore. four-stroke cycle.	M/S Zoroaster. two-stroke cycle.
Type		
Number of cylinders	6	4
Cylinder diameter	24·4 in.	19·8 in.
Stroke	38·4 in.	27 in.
Rated brake horse-power	1,250 at 125 r.p.m.	1,600 at 100 r.p.m.
Brake horse-power on test selected	1,232 at 123 r.p.m.	1,752 at 105 r.p.m.
M.E.P. lb. per square inch	91·9	99
Mechanical efficiency	79·8	83
Fuel consumption per brake horse-power, full torque	0·425	0·41
Do., three-quarter torque	0·469	0·412
Do., half-torque	0·517	0·42
Thermal efficiency, brake horse-power basis	31·1	34·6
Total weight of engine and flywheel	450 tons.	175 tons.
Weight per brake horse-power	900 lb.	225 lb.

Mr. Day thought it would be of interest to members to know from those comparisons how much the two-stroke cycle engine had been developed in recent years. He trusted it would be possible for an equally complete series of tests to be made of an engine of that type.

Mr. Byrne said he ought to begin his remarks with an analysis of the table given by Mr. Charles Day. Firstly, he had noticed the weight per brake horse-power was 900 lb. That was wrong; it ought to be 400 lb. And then, in regard to the other table given by Mr. Day, the fuel consumptions could not be compared at all, because the Sycamore engines were at various loads and also varying rates, whereas the 200 brake horse-power engines were at constant rates. The conditions were therefore absolutely different, and not comparable.

With regard to the maximum pressures, it would be noticed that a very high maximum pressure of 600 lb. per square inch was obtained on Test 15, and it had been found that the fuel consumption then was very big—about 0·44 lb. per brake horse-power. They had dropped the pressure, and the result was that the fuel consumption immediately dropped to 0·425. Actually now the Sycamore was running at about 550 lb. maximum pressure. It would be noticed that the machinery weight and the general specification of the Sycamore was very substantial. His firm had made certain that the reliability of those first two vessels should be absolutely unassailable, and they had followed that policy throughout.

With regard to the fuel consumption, they had tried to lower it and had spent about six weeks of very hard work, as probably Mr. Freeman would know. They had tried all sorts of things—changed piston-rings, slackened bearings, and had altered the fuel valves; and they could not with low maximum pressures produce a fuel consumption below that shown—0·425. They had now tried four engines of that type, and were convinced that that was the fuel consumption of the engine. Incidentally, there were other builders on the North-east coast who had thought that they got 0·431, but actually found that they got less when they analysed matters very carefully. Mr. Freeman had made some remarks with regard to piston-rings. They had started with those engines with a lapped form of piston-ring, and thought they could improve the results by having diagonal rings, but they had obtained no better results. They had, however, obtained no worse results. They found out that they had to have an ample axial clearance of the ring. They had also found that it did not really matter what joint they had, they could not get a scrap of difference in the fuel consumption. They gave the ring about 0·004 in. clearance. Most land practice was very much less than that.

With regard to fuel consumption on the boats at sea, the Sycamore had completed two round trips—a distance of about 2,500 miles—and the fuel consumption was 11¼ tons. The fuel consumption of the main engines was exactly as it was in the shops, and that was with a fully loaded ship.

Mr. Butterworth said that, with regard to piston rings, he thought it had long been known in land practice that no matter how the gap was cut down no marked difference was obtained in the leakage, and on practically all land engines of that type they were using diagonal gaps at the present time. He said they had come to the conclusion that the increased efficiency Mr. Byrne had obtained was due to the fact that the gases escaped past the piston rings, and, owing to the piston rings being slack, the gases got behind the rings and packed the rings out, thereby securing a more gas-tight joint on the cylinder wall.

Professor Stoney said he was essentially a steam man, and would like to put in a word for steam. The ordinary installation of a boiler and engine on board ship had no economiser; sometimes there was a small air heater, but the condensers were cramped so that the vacuum was generally rather poor in comparison with land practice, and, on top of that, accurate measurements were scarcely ever made of the steam consumption, or oil and coal consumption, so that marine engineers, as a rule, were very much at sea as to what the actual efficiency of their engines was. They took indicator diagrams, but those were generally taken just after the fires were cleaned, and the results obtained were often very much out of proportion.

He happened to have the figures of the tests of a liner of 16,400 tons, 17 knots and 12,500 h.p., with double-geared turbines. The steam pressure was 220 lb. and the superheat was 100 deg. F.—about normal. She took 10·05 lb. of steam per shaft horse-power and 0·876 lb. of oil. The oil was 19,000 B.Th.U. The overall efficiency of the engines was only 67 per cent. The boilers also showed only 67 per cent. What were the reasons of that? Firstly, they had only a vacuum of 28·3 in., with a sea temperature of 57 deg. On land, with that water temperature, they should get 28·9 in., and Professor Stoney thought that if they did not use the enormously wasteful steam-driven auxiliaries that were common, and had electrically-driven auxiliaries, they should get 73 instead of 67 per cent. There was also no reason why the superheat should not be raised to 200 deg. That would reduce the consumption of oil with the steam boilers to 0·73 lb. A boiler on land in a power station with 67 per cent. efficiency would be looked upon as ridiculous. Boilers on land with good economisers, air heaters, &c., gave from 84 to 88 per cent. The tests on the Barton boilers were over 88 per cent. At sea, by proper arrangements, they should get boilers of 80 per cent. That would reduce the oil per shaft horse-power to 0·61 lb. Another thing was intermediate feedheating; that should, in fact, take another 5 per cent., which would make the oil per shaft horse-power 0·58 lb.

In the Report it would be found that the oil per shaft horse-power was 0·55 lb. on the Sycamore. A steam installation properly put in would have only 5 per cent. more oil consumption than the Sycamore. The weights on board the Sycamore were very large. The total amounted to under 3 h.p. per ton. One could get down very much lighter than that with suitably constructed marine engines and boilers, and he was of opinion that if one put in the extra weights necessary to get real economy and took accurate readings of the water, of the oil and of the torsionmeter, so as to get the actual consumption, and worked as in a power station on land, one would get with a steam installation very close to the results obtained on the Sycamore. Accurate tests and accurate measurement were the only means of finding out how to cut down consumption; these had not been applied at sea with regard to steam.

Another thing he wished to draw attention to was the complicated mass of pipes, pumps, &c., at very high pressure required with Diesel engines. He had

counted the number of nuts that there were in a cylinder on the Sycamore as it lay in the shops, without including the holding-down bolts. He had counted 26 nuts, and of those 8 could not be got at without dismantling something else. The result was conclusive: before a Diesel could really become a thoroughly practicaly proposition it would have to be simplified and made so that it could be easily worked and looked after.

Mr. Mohn, referring to Table XIX, said that in Test 15, the amount of heat that went to the jackets was 18,400 B.Th.U., and to the manifold 17,100 B.Th.U.; that did not seem to be in proportion. Looking at the temperatures, it would be found that a drop in temperature between the cylinder and the manifold was only about 38 deg. Turning to the question of the weight of the engines, he would ask if with two engines of 1,250 h.p. 24 tons of flywheels were required for marine work? Personally, he had experience with some 1,500 h.p. engines, and the flywheels were just about the same. A weight of 20 tons for the lubricating oil system also seemed unreasonable. The lubricating oil in the system was 14 lb.

With regard again to Table XIX, on the last test there was no heat going to the jackets at all, either for the manifold or the pistons. It seemed from that that the tests had been started too soon, and that the engine had not been working properly when the test had been started. The lubricating oil consumption of the engine given for the shop tests seemed a very good result, but the consumption taken at sea was not very good. For the power cylinder it had gone up from 3·1 to 6¼, and from the air compressor just about the same.

Mr. Kersey referred to the power taken by the air compressor. He stated that in one case 9 per cent. of the total brake horse-power developed by the engine was expended in driving the compressor. In Trial No. 2 of Table XXVI it amounted to 13 per cent. of the total brake horse-power, that would be otherwise usefully expended on the propeller shaft. That seemed to him to be something of an argument for conducting the experiment. It seemed very obvious that the horse-power expended in solid injection would be considerably less than 9 per cent. of the total brake horse-power.

Referring to Fig. 29, what seemed to him somewhat remarkable was that the friction torque appeared to be diminishing as the speed increased. He was not sure whether that was common experience. It seemed to him to require some explanation. Either the friction must be reduced, owing probably to reduced load on the pistons reducing the friction of the piston rings in some way, or the viscosity of the oil must be reduced by an increased temperature, which did not appear to be probable in that case with a comparatively small increase of speed, or there must be a somewhat thicker oil film reducing the coefficient of friction. He was not quite sure whether all these effects could be produced by increasing the speed, but he would like to have further information. Obviously, the relation could not hold for more than a very small range of speed. If it did, by speeding up the engine sufficiently, friction could be eliminated altogether, which was quite out of the question. Another thing that struck him as rather extraordinary was that the slopes of those lines were different. This diagram showed at ¾ torque a rate of diminution of 120 lb. ft. compared with a decrease at ¼ torque of 76. With ¾ torque the diminution was 60, and appeared to be the same on full torque. That rate of diminution seemed to vary almost inversely as the torque.

He would like to mention the exhaust gas analysis. He thought that they might have a very considerable amount of confidence in the results as given. It was fairly well known that there was a definite relation between the exhaust percentage, the CO_2 percentage, and the CO percentage. That could be expressed in the form of an equation. It was very useful to have some sort of check as to the relation that should occur between the three. Using that particular equation, he found that the results were very consistent, and it was also possible to estimate the percentage that should be added to the CO_2 in order to bring it up to the correct amount. That, again, agreed with the formula used. Therefore, he thought that they might have a very large amount of confidence that the exhaust gas analyses were at least reasonably correct. It was not desirable that they should have to make corrections of that kind, but he thought it was worth while just mentioning that that appeared to be consistent.

Mr. Orton said that the first thing that had struck him was with regard to the weight, and he would suggest that the reason why Mr. Charles Day had given 900 lb. per horse-power was that he perhaps meant the total weight of the machinery, and they were thinking about the weight of the engine itself. On the other hand, he might have divided that figure of the weight of the engine by 1,250 instead of 2,500. The actual weight per horse-power of the engine itself and flywheel was 400 lb. All the same, all engine makers must recognise that 400 lb. was an enormous figure per horse-power, although it was not by any means unusual. It was perhaps interesting to make a little comparison with an aeroplane engine which got its horse-power at the rate of 1·4 lb. per brake horse-power; this showed what a lot they had yet to learn about Diesel engines.

The high maximum pressure had also been referred to in some of the indicator diagrams. That point had struck him also. It had always been taken in Diesel engine practice that one did not get any increase of pressure during combustion, and that had always been thought ideal. During the last few years, however, there seemed to have been a tendency to try to get that increased maximum pressure from the beginning of combustion, and there was no doubt at all that doing that did bring down the fuel consumption. In the particular case to which Mr. Byrne had referred, he (Mr. Orton) thought that it would have been better to have the compression pressure higher. He noticed it was rather lower than that usually adopted on normal Diesel engines. If they were going to have higher pressures at all, why not put them on to compression? In that way, they could get equally good fuel consumptions.

There was one point of interest about the diagram for fuel consumptions (Fig. 23). It would be noticed on looking at that diagram that the line of fuel consumption per indicator horse-power had a very considerable curl up at the low torque end. That was rather curious. In Diesel engines on land the fuel consumption per indicator horse-power was always better at low loads than at high loads, owing to very much better access of oxygen and improved conditions for combustion. In this case, the tendency was shown right down to half rate torque; and when one got to the lowest figure, ¼ torque, a very great curl up was shown. He could not see any reason why it should be so, and had come to the conclusion that there might be an error in that figure, and would very much like to know if that were so.

In Table XVIII, which referred to mechanical and thermal efficiencies, the figures on the bottom line were interesting. These were related to volumetric efficiency, and he took it that they had been estimated from the exhaust gas analysis, and supposed that they were accurate within a reasonable degree. The CO_2 would probably not make very much difference. If one lost on it with CO_2, it would not affect the estimate of the weight of air taken in, since he thought that the molecular weight of CO_2 was not very different from that of the average of the acids, and, in any case, it only amounted to about 5 per cent. for the total. The figures might be taken as right. They had struck him as being very much lower than would be accepted in a normal Diesel engine. Might not some reason be found for that low volumetric efficiency? Obviously, the space between the main valve and the deflector valve was lost space for the beginning of the suction stroke. That space was full of exhaust gases, and there were two such spaces, so that those volumes would amount to about 5 per cent. They had quite an appreciable effect on volumetric efficiency, and they might bring those figures up to something more like what one would have expected from a normal two-valve type engine. He wondered if that point had been gone into as part of the investigation, because that particular feature was, of course, a speciality of that particular type of engine. Probably, when one was testing another type of engine later, similar figures with which to compare them might be obtained, which would give valuable information about the relative value of that system of exhaust.

Mr. Wright Baker said there was just one measurement he would like to query, and that was the measurement of the exhaust gas temperature. In some experiments on petrol engines fitted with thermo-couples and with exhaust gas column, the exhaust gas column always gave exhaust gas temperature higher than those given by the thermo-couple. At the same time when the exhaust gas column showed the temperature to be falling, the thermo-couple showed the temperature to be rising. He did not know whether there were any similar comparative results on a larger engine, but it would be interesting to know.

Mr. Bevan said there were two points in the paper that he would like to draw attention to. One was in connection with Fig. 31, connecting exhaust gas temperature and fuel per minute. It had struck him on looking at the diagram that some of the points appeared to be a long way from the line passing through the majority points. In Table XII of exhaust gas temperatures and in Trial A.5, the temperatures given for the cylinders showed a very considerable difference between the cylinder at the forward end, No. 1, and cylinder No. 5, from 500 to 647 deg. At the same time the average temperature for all the cylinders was 583 by the mercury thermometer and 598 by the electric pyrometer, and in all the other cases the readings by the mercury thermometer were higher than those by the pyrometer. It seemed to him that it might possibly indicate that the trial had been carried out before the conditions had settled down.

There was one other point in connection with the indicated mean pressures. The mechanical efficiency which one would expect from the running down test would be higher than the normal, because in the cylinder in which the fuel was not injected the compression pressure would still be acting on the top of the piston, and a certain amount of indicated work would be done by that compressed air, thus leading to a higher mechanical efficiency than for the engine running under normal conditions. That suggested that the indicated thermal efficiency as given for most of the trials from the normal indicator diagrams was too high, and pointed to the fact that the indicator gear was not of the best. If one took the figures as given, 93 lbs. per square inch for the normal indicator gear, and 101 per square inch for the more elaborate gear, and compared those for Trial 15 of Table XVIII, in each case the indicated mean pressure was given as 91·9 lbs. per square inch, the correction, taking into account the new gear, would amount to about 99 lbs. per square inch, and give a mechanical efficiency of 73·5 as against 79·8, 73·5 comparing very well with the 73·2 obtained by the cutting out test.

Mr. Harrison said that a question had been asked regarding the relative merits of the solid injection system and the independent pump system. Undoubtedly, the successful working of the multi-cylinder heavy oil engine depended to no small degree on the ease with which the amount of fuel could be distributed to the various cylinders, so that the power developed in each cylinder bore a correct relation to the total power developed by the engine, but his experience was that the common line system lent itself much more readily to that distribution than the independent pump system. He had been fortunate enough to take to sea one of the first boats that was ever fitted with the common line system. That boat's engines were made with a pump of sufficient capacity to supply to the engine about double the amount of fuel that it would ever require, and the surplus fuel was allowed to discharge whilst the relief valve discharged the pressure. That was a most unfortunate arrangement, and gave anything but satisfaction. The pressure fluctuated so much that most unsatisfactory running resulted. But when that difficulty had been overcome, the engines in service proved themselves to be the best type that were ever put in a submarine boat, and all boats that were fitted then with independent pumps were to some extent converted. Those pumps were coupled together. He did not think there was any question as to which system was the better one in practice. It was so much easier to distribute the power equally between the various cylinders.

A question had been asked about the weight. In those particular engines the weight was from 60 to 80 lbs. per brake horse-power against the 300 to 400 lbs. mentioned. In that case the speed was about 1,100 r.p.m. The engines had run to the greatest satisfaction of everyone concerned, after the initial difficulties of fuel consumption had been overcome.

CONTRACT.—The Relay Automatic Telephone Co., Limited, of Marconi House, Strand, London, W.C. 2, has received an order from the Minister of Posts and Telegraphs, Berlin, to supply private branch automatic exchange apparatus, constructed to the same specification as the relay installations supplied to the British General Post Office.

LOCOMOTIVES FOR EGYPT.—The Egyptian State Railways are advertising for five passenger engines for the Luxor-Assuan line. The gauge of this line is 3 ft. 6 in. The Commercial Secretary at Cairo reports that the adjudication of these engines takes place in Egypt on January 13, 1925, and that the total cost estimated on the last supply price is approximately 20,000*l*.E delivered in Egypt. Specifications can be obtained from the Inspecting Engineer, Egyptian and Sudan Governments, Queen Anne's-chambers, Westminster, S.W.1, at the price of 10*s.* each.

EXHIBITION OF COLONIAL AND FOREIGN PRODUCTS AT LAUSANNE.—Under the patronage of the Swiss Government, an International Fair of Colonial and Foreign Products is to be held at Lausanne, between June 27 and July 12 next year, in conjunction with the annual Swiss Food Fair. Exhibits will be classified under six main headings: Agricultural and sea food products; other agricultural and sea products; horticultural products; forest products and industries; mineral products; and colonial arts and crafts. Owing to its central position in Europe on the main Continental railway routes, Lausanne is an admirable site for an exhibition of this character, and the clientele built up by previous Lausanne fairs should ensure a large attendance of buyers. The Department of Overseas Trade is of opinion that the Fair should offer a good opportunity to British firms dealing in food products and raw materials. Full particulars as to the space available can be obtained on application to the Fair Committee, 2 Rue Pichard, Lausanne.

THE MOTOR LAUNCH "INVERMIRA."

A VERY serviceable and seaworthy motor-launch recently designed and constructed by Messrs. Harland and Wolff, Limited, of Liverpool, for Messrs. Andrew Weir and Co., Limited, is illustrated in Figs. 1 to 10 on this and the opposite pages. The boat, which is intended for use off the coast of Venezuela, has an overall length of 55 ft., a breadth of 10 ft. 9 in., a moulded depth of 5 ft. 8¼ in., and a maximum load draft of 4 ft. 6 in. She is constructed of steel, with a teak deck, all exposed woodwork being also of teak. The launch is fitted with an oil-engine, but in addition is cutter rigged, so that in favourable weather she can be navigated without the engines. The sail arrangements are shown in Figs. 1 to 3. A section of the vessel is given in Fig. 4. The propelling plant consists of a Gardner four-cylinder engine of the semi-Diesel type, capable of developing 96 brake horse-power at 370 r.p.m., and situated centrally in the boat. Immediately forward is the fuel pump and compressed-air equipment. Overhead a service tank carries 33 gallons of fuel, reserve fuel tanks being situated at engine room floor level. Good head room is available in the cabin, which is provided with sleeping accommodation. The furniture consists of a sideboard, crockery lockers, table, lockers for bedding, and all conveniences. The cabin is well ventilated by two cowls. A stairway leads up to the main deck just in front of the steersman's shelter. The latter is fitted with sliding windows and portable chart tables. In the fore-peak, fresh-water tanks and a chain locker are fitted. Aft of the engine, there is a water-cooled silencer, from which the exhaust pipe passes to the stern of the launch. The hull has three watertight bulkheads, and the after compartment, which is entered through a large hatch, is fitted for carrying stores or light cargo.

A plan of the main deck is given in Fig. 5, on which the positions of the paraffin and fuel oil filling pipes are shown. Two towing posts are fitted to each side of the deck, a slip towing hook being fixed at the after end of the engine casing. A number of folding seats are also provided, and a small dinghy is carried. In Fig. 6, which is a plan just below the main deck, further details are shown. The main fuel tanks have a capacity of 470 gallons of fuel, sufficient to operate the launch for three days. The paraffin tank carries a supply of 50 gallons of oil, while 20 gallons of lubricating oil are provided for in a small tank situated at the port side. The series of cross-sections, Figs. 7 to 10 indicate the lateral disposition of the fittings of the vessel. The speed of the launch is 10 knots, and after satisfactory tests had been carried out in the Mersey, she proceeded under her own power to Glasgow, whence she is to be shipped to her destination.

THE MEASUREMENT OF THE PRESSURE OF THE WIND ON STRUCTURES.*

By THOMAS ERNEST STANTON, C.B.E., D.Sc., F.R.S., M.Inst.C.E.

THE present Report is the third section of the investigation on wind-pressure commenced at the National Physical Laboratory in 1903. The first Report† described experiments in a wind-channel on small-scale models of structures and gave information on the relative effect of the form and distribution of the solid surfaces of structures. The second Report‡ was devoted to tests in the open air on plates and model roofs and girders up to 100 sq. ft. in area, and showed that the effect of the difference in size between these structures and the small-scale models used in the wind-channel tests was practically negligible, provided the velocity of the wind was uniform in a direction perpendicular to its direction of motion.

The third Report deals with the effect of the lateral variations in velocity of actual winds, and describes the determination of the mean pressure of the wind on the high-level footway girders of the Tower Bridge and the relation of this mean pressure to the pressure at a reference point in the surface of the girder. It is shown that for bridges of spans up to 250 ft., the effect of the lateral variation in velocity of the wind is not sufficient to admit of any considerable reduction in the wind-pressure factor on this account, and the conclusion is reached that until further experiments have been made on still larger structures, of spans exceeding 2,000 ft., wind-pressures should be calculated from the records of anemometers on the site and on the assumption of a velocity of wind uniform over the whole structure. An illustration is given of the calculation of a wind-pressure factor on the lines recommended.

* An abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, December 16, 1924.
† Minutes of Proceedings Inst.C.E., vol. clvi, page 78.
‡ *Ibid.*, vol. clxxi, page 175.

THE MOTOR LAUNCH "INVERMIRA."

CONSTRUCTED BY MESSRS. HARLAND AND WOLFF, LIMITED, LIVERPOOL.

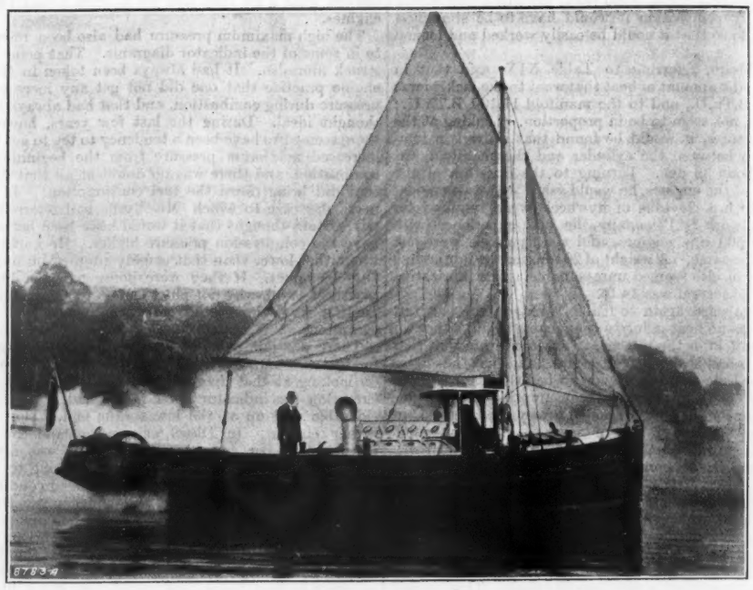


FIG. 1.

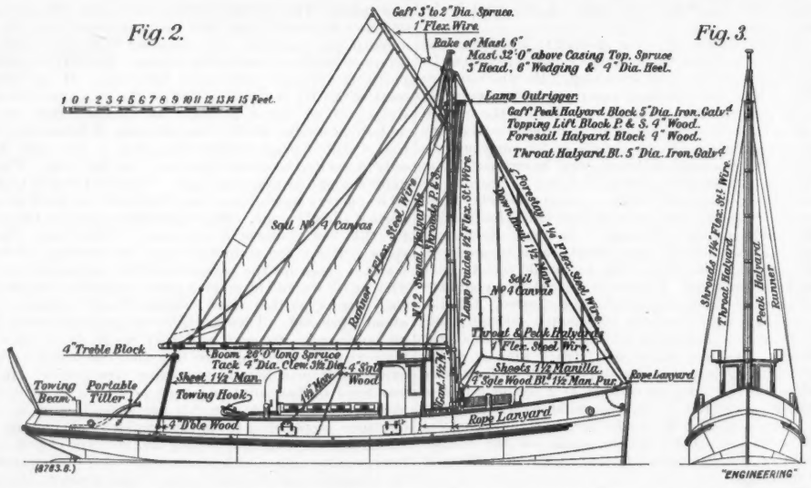


Fig. 2.
Fig. 3.
Gaff 5" to 2" Dia. Spruce.
1" Flex. Wire.
Bake of Mast. 6"
Mast. 32'0" above Casing Top, Spruce
3" Head., 6" Wedging & 4" Dia. Heel.
1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Feet.
Lamp Outrigger.
Gaff Peak Halyard Block 5" Dia. Iron, Galv.d
Topping Lift Block P. & S. 4" Wood.
Foresail Halyard Block 4" Wood.
Throat Halyard Bl. 5" Dia. Iron, Galv.d
Sail No 4 Canvas
Rocker 1" Flex. Steel Wire
No 2 Steel Pennant P. & S.
Lamp Guides 24 Flex. 8/1 Wire.
Foresail 1½" Flex. Steel Wire
Sail No 4 Canvas
Throat & Peak Halyards 1" Flex. Steel Wire
4" Treble Block
Boom 26'0" long Spruce
Tack 4" Dia. Clew 3½ Dia. 4" Slot
½ Mast
Wood
Sheet 1½ Man.
Towing Beam
Portable Tiller
Towing Hook
Sheets 1½ Manilla.
4" Style Wood Bl. 1½ Man. Pur.
Rope Lanyard
4" D'ble Wood
Rope Lanyard
Shrouds 1⅝" Flex. 8/1 Wire
Throat Halyard
Peak Halyard
Runner
(8783.8.)
"ENGINEERING"

THE LATE MR. ROBERT DUNCAN.

WE regret to record the death on December 4, at Logieaston, Bridge of Allan, of Mr. Robert Duncan, senior partner of the firm of Messrs. Ross and Duncan, of Whitefield Works, Govan. Mr. Duncan was born on October 5, 1850, and at the age of seventeen entered on a five years' apprenticeship with Messrs. Alexander Chaplin & Co. at Cranston Hill Engine Works, Glasgow. At the completion of this period, during which he gained experience in the shops and drawing office, he studied at Glasgow University, securing the certificate of proficiency in civil engineering and mechanics at the end of 1874. Further experience gained in the course of the following eighteen months as a draughtsman on locomotive work and on the design of plant for sugar factories was a preliminary to his commencing business in partnership with Mr. W. Ross at Hyde Park Street Engine Works, Glasgow. This partnership, however, was dissolved in 1880, after which year Mr. Duncan carried on the business on his own account, removing in 1883 to Whitefield Works. Here the design and construction of steamers, together with propelling machinery, has been carried on until the present time. The engines built ranged up to 700 i.h.p., and were supplied to the British Admiralty, the Crown Agents for the Colonies, and foreign governments. Mr. Duncan took a very keen interest in engineering developments from the industrial as well as the technical standpoint, and was a member of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the Institution of Civil Engineers. In 1906 he successfully contested Govan as a Conservative and entered the House of Commons. He represented that constituency until the dissolution in 1910.

PHYSICAL SOCIETY EXHIBITION.—The annual exhibition of the Physical Society of London and the Optical Society, which is to be held on January 7 and 8, 1925, at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, London, will be open in the afternoons from 3 to 6, and in the evenings from 7 to 10. Mr. F. Twyman will give a lecture on "Some Experiments with Interferometers," at 4 p.m., on January 7, and at 8 p.m. on January 8. Mr. C. F. Elwell will lecture on "Talking Motion Pictures," at 8 p.m., on January 7, and at 4 p.m., on January 8. These lectures will include demonstrations. Over fifty firms are exhibiting scientific apparatus. Admission will be by ticket only. Invitations have been given to the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Chemical Society, the Radio Society of Great Britain, the Röntgen Society, and the Faraday Society, and members should apply to the secretary of the Society to which they belong for tickets. Others interested should apply to Professor A. O. Rankine, Hon. Secretary of the Physical Society, at the Imperial College of Science and Technology.

THE MOTOR LAUNCH "INVERMIRA."

CONSTRUCTED BY MESSRS. HARLAND AND WOLFF, LIMITED, LIVERPOOL.

(For Description, see opposite page.)

Fig. 4.

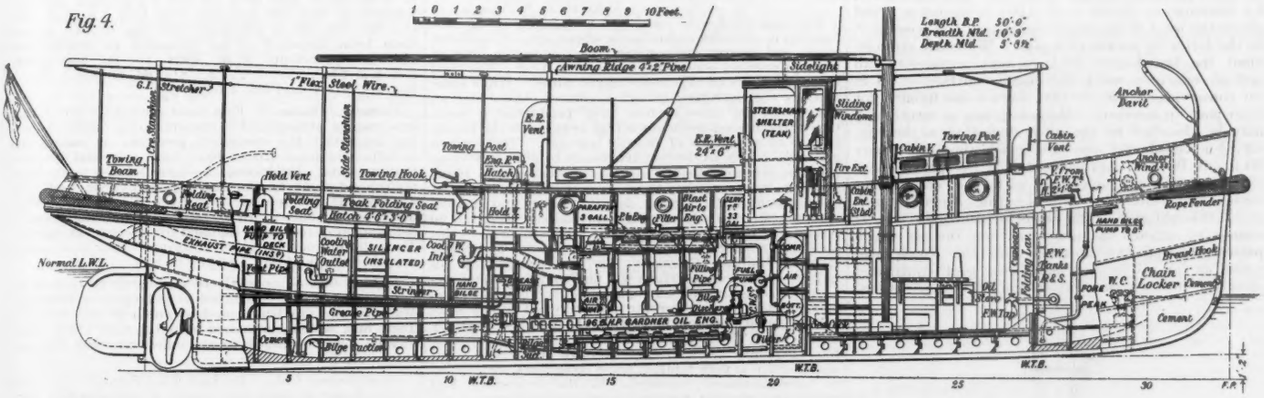


Fig. 5.

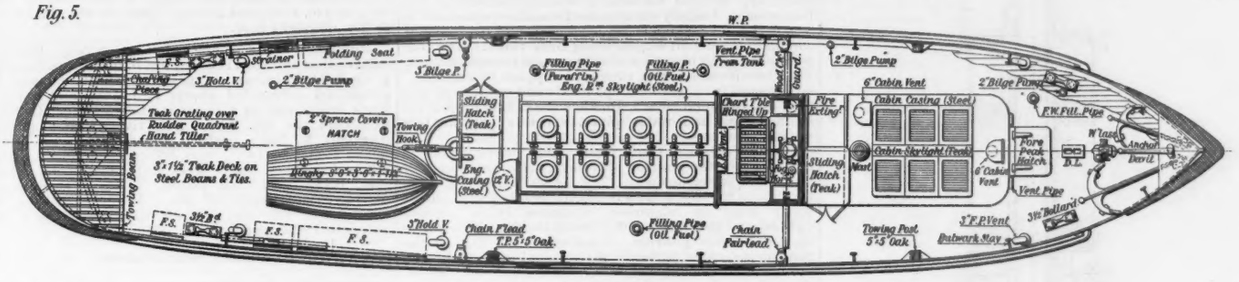


Fig. 6.

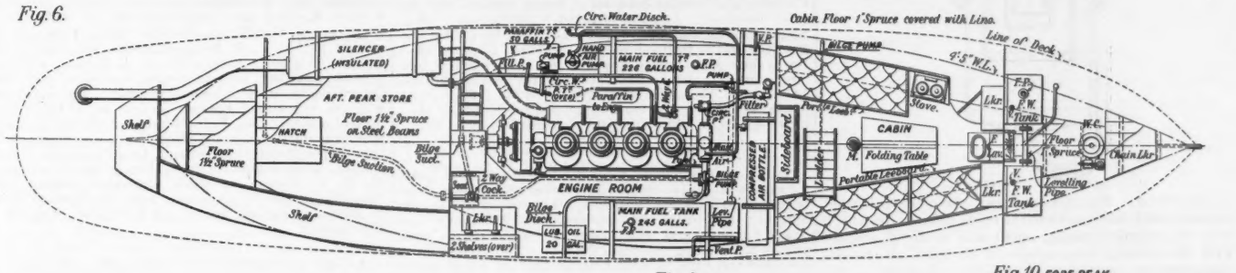


Fig. 7. AFT. PEAK LOOKING AFT.

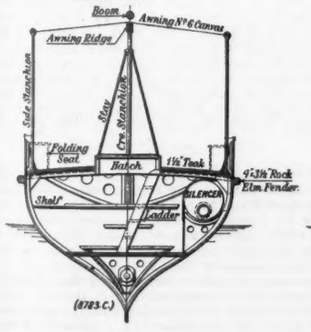


Fig. 8. MIDSHIP LOOKING AFT.

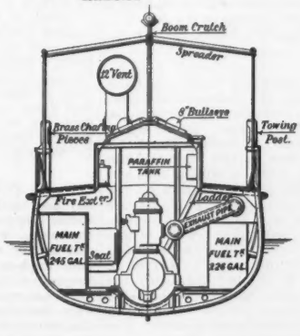


Fig. 9. CABIN LOOKING FOR^D

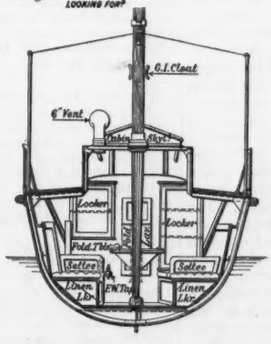
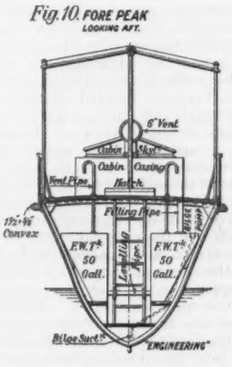


Fig. 10. FORE PEAK LOOKING AFT.



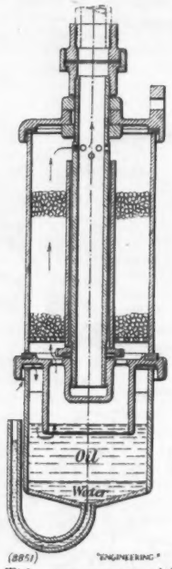
NEW BRIDGE OVER THE TYNE.—At the meeting of the Newcastle City Council on Wednesday, December 3, it was agreed to accept the tender of Messrs. Dorman, Long and Co., Limited, of 571,225*l.* for the construction of a bridge connecting Newcastle and Gateshead. The accepted tender was the lowest submitted, the highest being 743,938*l.*

DOUBLE-ACTING DIESEL ENGINES.—The production of 13,500 shaft horse-power from only two six-cylinder Burmeister and Wain four-stroke double-acting Diesel engines in the recently launched Swedish-American Line motorship Gripsholm, indicates that a distinct advance on existing marine oil engine practice has been achieved. By adopting a new method of piston cooling, permitting higher working speeds, and the double-acting principle it has been found possible to obtain over 1,100 h.p. from each cylinder of these engines. The cylinders are 33 in. in diameter, the stroke being 59 in. The Gripsholm was built by Sir W. G. Armstrong, Whitworth & Co., Limited, of Newcastle-on-Tyne. The vessel, which is built to the highest class in Lloyd's Register, is 17,000 tons gross and has a length of 550 ft., a breadth of 74 ft., and a depth of 42½ ft. from the bulkhead deck, and will constitute the first motor-driven passenger and mail ship in the North Atlantic trade. Sir J. H. Biles and Co., of London and Glasgow, acted as consulting engineers to the owners.

THE INSTITUTE OF PATENTEES.—Arrangements have been completed whereby members of this Institute in any part of Great Britain and Ireland may obtain free legal advice on any matter appertaining to patents, designs, or trade marks. This advice can be given either by correspondence or by personal interview. Arrangements have also been completed to enable members to have a cursory search made at the Patent Office, regarding any invention. This search has been divided into two classes: (1) A cursory search for the fee of 10*s.* 6*d.*, for which will be submitted to a member numbers and dates of specifications to which he should refer before going ahead with his invention. (2) A more extended search for the sum of 1 guinea, for which a member will receive numbers and dates of specifications appertaining to the inventions, together with the report. In each case the number of years which the search has covered will be stated. In view of the extreme cheapness of the latter service, the Institute reserves the right to accept or refuse any request for a search under the above conditions. The address of the Institute is 44, Great Russell-street, London, W.C. 1.

CALCIUM-CHLORIDE BREATHERS FOR TRANSFORMERS.

IN order to prevent the insulating properties of the oil used in transformer tanks from being impaired by the absorption of moisture from the atmosphere, various expedients have been adopted to stop the free access of air to the surface of the oil. It is customary, for instance, to install a so-called conservator vessel above the level of the transformer tank and connect it to the latter by means of a pipe. With this arrangement the transformer tank is kept completely full and air can only reach the smaller surface of oil in the conservator vessel, so that there is less liability for it to pick up moisture. Moreover, any moisture that may be absorbed by the oil is deposited in the conservator vessel and does not reach the transformer tank. A further improvement was the provision of "breathers" in connection with the conservator vessel, and containing a desiccating chemical such as calcium chloride. The object of the latter was, of course, to extract the moisture from the air which passed through the breather into the conservator vessel as the oil in the transformer tank contracted after the load on the transformer had been reduced



or thrown off. This arrangement, although a distinct improvement, suffered from the fairly obvious drawback that the chemical drying agent was in direct contact with the external atmosphere at all times, so that its desiccating properties were rapidly exhausted in the useless extraction of moisture from the air of the compartment in which the transformers were installed.

To retain the advantages of the calcium-chloride breather while avoiding the drawback just referred to, Messrs. Ferranti, Limited, of Hollinwood, Lancashire, have recently introduced a form of breather the design and construction of which are illustrated in the accompanying engraving. Its special feature, which will at once be apparent from the figure, is the provision of an oil seal through which the air drawn into, or expelled from, the conservator vessel must pass, but which effectively cuts off communication between the calcium chloride and the external air at all other times. The chemical is thus only called upon to absorb the moisture from the comparatively small quantity of air entering the apparatus, so that it remains in a serviceable condition for a long period. Another important point is that the liquid resulting from the absorption of moisture by the calcium chloride drains from the latter into the oil seal, collecting at the bottom of the latter and eventually escaping through the overflow pipe shown in the illustration. This, of course, serves to maintain a constant level of oil in the sealing chamber.

The breather referred to is connected by the pipe shown at the top of the illustration to the upper part of the conservator tank. Its construction can be followed from the figure with but little explanation, but it should, perhaps, be mentioned that the air enters between the rim of the oil-seal chamber and the inner edge of the flanged bottom cover of the calcium-chloride chamber, passing through the apparatus in the direction indicated by the arrows. The flanged-bottom cover also secures the oil seal, and by unscrewing it and removing the latter, access is obtained to the running nut holding the calcium-chloride container in position. By removing the running nut the container can be withdrawn, recharged, and replaced in a few minutes. It should, perhaps, be mentioned, in conclusion, that Messrs. Ferranti have applied for a patent in connection with the breather described above.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—As compared with a month ago the position in this area undoubtedly shows signs of improvement, and current indications give rise to the hope of more prosperous conditions in the New Year. The steel trade continues to experience mixed times. While some sections are operating at full capacity, others find an outlet only for three or four days' production a week. One of the busiest branches is that engaged in the manufacture of all classes of railway material. The outlook generally in this section is particularly bright considering that, in addition to the advent of business on home account, overseas schemes in connection with transport development are taking a definite shape, and if local makers can suitably arrange quotations there is no reason why they should not benefit. Several firms in this area have received contracts from the London and North Eastern Railway Company, for the construction of railway goods wagons which will find continuous employment for some time ahead. Makers of shipbuilding steel, marine castings and turbine parts do not report such robust conditions, but state that the position is slowly improving. The demand for automobile steel and fittings tends generally to expand, and though business on overseas account is very limited, home consumers are inclined to take increased tonnages. In the implement and machinery sections business is mainly confined to the Dominions. Colliery development continues apace and is responsible for makers of pit head gear, and haulage and winding equipment, experiencing busy times. The tool trades are doing better on both home and foreign account. The Colonies are taking increased supplies of engineers' and general tools, garden implements and excavating and road-making appliances. Builders are calling for general ironmongery, rain-water pipes, concrete and mortar-mixing machines.

South Yorkshire Coal Trade.—An improvement is noticeable in the position all round, and most classes of fuel are in better demand. The active demand by home consumers for best steams is maintained, but the amount going away for shipment continues below normal. Cobbles and nuts are steadily strengthening, while slacks are in a better position. Considering the time of the year house coal is far below the seasonal level, and hopes of an improvement before Christmas are not bright. Foundry and furnace coke are in better request, and gas coke continues a good market. Quotations: Best branch handpicked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 27*s.* to 32*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 20*s.* 6*d.* to 23*s.*; Derbyshire hards, 20*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 9*s.* 6*d.* to 13*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

THE ROYAL SANITARY INSTITUTE.—The subject given for essays in competition for the Henry Saxon Snell Prize of this Institute in 1924 was "Improvements in the Sanitary Conditions of Underground Dwellings and Small Underground Workshops." Eleven essays were received, including one from Canada. The Council have awarded the prize of fifty guineas and the silver medal of the Institute to Mr. E. Thomas Swinson, M.R.San.I. Two of the other essays showed considerable merit, and the Council have decided to recognise this by making a supplementary award of a bronze medal of the Institute to each of the writers, Mr. Edward E. Barks, A.R.I.B.A., and Mr. F. R. Jelley.

THE SUN LOSING MASS.—According to the doctrine of relativity, mass and energy are convertible terms, and a star which is radiating energy away in the form of light is therefore steadily losing mass. In an article which appeared in a recent issue of *Nature*, Dr. J. H. Jeans, Sec. R.S., calculates that in this way the sun is losing mass at the rate of about 4 million tons per second. As a consequence the sun's attraction on the earth is steadily diminishing. In another 1½ billion years (taking the English definition of a billion as a million million) the sun will have only nine-tenths of his present mass and the earth's orbit will have expanded by one-ninth and the year be prolonged to 451 days. The above view accords, it is pointed out, with the fact that the luminosity of a star seems to depend on its mass alone. Sirius has 2½ times the mass of our sun and 36 times his luminosity. He cannot maintain this rate of radiation indefinitely and Dr. Jeans states that some day the rate will have fallen to that of our sun of to-day. At the same time, Sirius will have lost so much of his present mass in the form of radiation that he will only be as massive as our sun now is. Dr. Jeans suggests that by far the greater part of the energy now being radiated away from the various fixed stars, is derived from what he calls sub-electronic stores of energy. By this is meant such energy which would be liberated if, for example, the single electron of the hydrogen atom were able actually to fuse with the positively charged nucleus, thus annihilating both. If such stores of energy are being drawn upon, he concludes, that the evolution of the cosmos, as we now know it, may have taken more than a million million years, and that consequently planetary systems like our own may be fairly freely distributed in space, instead of being the exceedingly rare exception which previous mathematical investigations have indicated as probable.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Transactions in Cleveland pig-iron are on only a moderate scale, but such is usually the case about this season of the year. Supplies are not over-plentiful. Makers have practically no stocks to draw upon, and they are not particularly pressing business as they are generally well sold. Export sales are still difficult to negotiate, but one or two parcels have been disposed of for despatch to destinations abroad. Quotations show next to no movement. No. 1 is 87*s.*; No. 3 g.m.b., 81*s.* 6*d.* to 82*s.*; No. 4 foundry, 81*s.*; and No. 4 forge, 80*s.*

Hematite.—Sales of East-coast hematite are rather less readily arranged, but recent fairly good business has improved the statistical position, as substantial withdrawals from stocks have been essential to meet requirements. Producers, however, have still large undisposed-of accumulations at their yards, and they are anxious to liquidate these by further sales. Home needs are confidently expected to expand, and hope is entertained of improved demand for overseas shipments. Thus the outlook is rather cheering. Nos. 1, 2, and 3 are 88*s.* 6*d.*; and No. 1 is put at 89*s.*

Foreign Ore.—Imported ore is difficult to dispose of, but sellers are very disinclined to make price concessions. Market rates are based on best rubio at 22*s.* 6*d.* c.i.f. Tees, but, whilst consumers hold the view they could buy on lower terms, there are sellers who ask 23*s.* and even more for best rubio.

Blast-furnace Coke.—Durham blast-furnace coke is in rather better request, but supply is considerably more than ample, and good average qualities are still on sale at 25*s.* delivered here.

Manufactured Iron and Steel.—Generally trade in finished iron and steel is quiet, but in one or two branches a moderate business is passing, whilst demand for galvanised corrugated sheets is heavy, and sales of black sheets are on a much improved scale. Common iron bars are 12*l.* 10*s.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets, medium, 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 12*l.* 10*s.*; black sheets, 12*l.* 5*s.*; and galvanised corrugated sheets, 18*l.*

PERSONAL.—The Directors of the London and North Eastern Railway have appointed Mr. J. Miller to be Engineer of the North Eastern Area, York, in succession to Mr. C. G. Bengough, who will retire at the end of the present year. Mr. C. J. Brown, who is at present Engineer for the Great Northern and Great Central sections, is to assume control of the engineering work of the Great Eastern section in addition to his present duties. Mr. F. G. Randall, Assistant Divisional Superintendent, Liverpool-street, has been appointed District Superintendent, Southern District, Great Eastern Section, in succession to Mr. G. Keary, who is retiring.—Mr. J. M. Morton has been appointed Repair Works Manager to the Shipbuilding and Engineering Works of Messrs. Cammell Laird and Company, Limited, at Birkenhead.

A NEW ENGINEERING POCKET-BOOK.—We have received a copy of a new engineering pocket-book, entitled "Engineering Workshop Notes and Data," compiled by Messrs. E. and F. E. Pull. It is really a pocket-book in point of size, its 124 pages with limp covers only making a small volume measuring 4 in. by 3 in. by about a quarter of an inch thick. The book contains all the usual workshop data in a form convenient for reference. Its pages, with the exception of the index, are reproductions of hand-written tables, diagrams, &c., and though well done, are not so easily legible as if the matter had been set in type. The pocket-book is published by Messrs. Crosby Lockwood and Sons, at the price of 2*s.* 6*d.* net.

HORSE-POWER RATING OF MOTOR CARS.—On Wednesday last, the 10th instance, the Parliamentary Secretary to the Ministry of Transport, Lieut.-Col. J. T. C. Moore-Brabazon, M.P., received a deputation from the Royal Automobile Club, the Society of Motor Manufacturers and Traders and the Automobile Association on the subject of the revision of the existing formula for the horse-power rating of motor cars. Sir Arthur Stanley, who introduced the deputation, urged that a Select Committee of the House of Commons should be appointed to consider again the possibility of a motor-fuel tax, but Col. Moore-Brabazon stated that this question could not be re-opened by his Department at present. A request was then put forward for information as to whether, in considering a revision of the horse-power rating formula, a 20 per cent. reduction in the revenue now obtained from motor cycles and vehicles taxed on a horse-power basis might be aimed at. To this Col. Moore-Brabazon replied that when a reduction in taxation was possible, the class of vehicles referred to, up to and including those of 25 h.p., should be regarded as having the first claim to a reduction in taxation up to 20 per cent. He could not hold out any hope of an early reduction in taxation, but the Committee, in considering the revision of the horse-power formula might frame their proposals on the basis of the above recommendation, which was that of the Departmental Committee on the Taxation and Regulation of Road Vehicles.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trades.—The state of the steel trade of Scotland is not very cheery at the moment and little movement is now expected this year. Producers are all looking forward to January in anticipation of a buying movement coming on then, but it is very doubtful if such will take place, as it is most probable that any improvement in trade will be gradual and such expansion will be more satisfactory in every way. When it comes along, however, it will be most acceptable. In the meantime there is great difficulty in securing specifications for plates and sections, and mills are not being constantly employed. Makers of black sheets, both the light gauges and the galvanised sorts, continue busy, and although the bookings have not been so heavy of late, the tonnage on order is considerable. The future is being looked forward to with some confidence, as some markets are very bare of supplies. There is not much demand for the heavier gauges, and plant is intermittently employed. Prices all round keep steady and the following are the market quotations:—Boiler plates, 13*l.* per ton; ship-plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{5}{16}$ to $\frac{1}{4}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been no change for the better in the position of things in the West of Scotland malleable-iron trade and new business is still very scarce. In the re-rolled steel branch of the industry much difficulty is being experienced in picking up orders, and keen cuts have to be made to secure almost anything. The quotation for "Crown" bars is unchanged at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-iron Trade.—In the Scottish pig-iron trade the amount of fresh business passing is not very heavy, but the demand shows signs of improving. While the output is limited the stocks on hand can meet the current demands and still leave something over. It is fully anticipated that the beginning of the new year will witness a larger turnover. The home trade is not placing many orders at present, and quite a lot of the tonnage booked recently was merely for covering purposes. Prices are steady and are quoted as under:—Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry, iron, No. 1, 4*l.* 15*s.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, December 6, amounted to 2,345 tons. Of that total 2,245 tons went overseas and 100 tons coastwise. For the corresponding week of last year the figures were 682 tons to foreign destinations and 142 tons coastwise, making a total shipment of 824 tons.

Large Contract for Glasgow.—The Glasgow firm of Messrs. Duncan, Stewart and Co., Limited, engineers, has secured a large contract, amounting to about one million pounds sterling, for two new beet-sugar factories in England. These two refineries, which will cost about 500,000*l.* each, are to be built at Kidderminster and Spalding, and will be similar to the one the firm has erected this year at Nottingham for the same owners. It is anticipated that by September next the new factories will be ready to make white refined sugar. The bulk of the machinery will be manufactured in this country at the firm's works, and is estimated at about 90 per cent. of the total. The buildings will be steel-framed. The chairman of the sugar concern is Lord Weir, and Lord Invernairn, Sir John Baird, and Sir Ernest Jardine are directors, while the managing director is Mr. Talbot-Crosbie, Mosely, Kidderminster.

Clyde Shipbuilding.—Messrs. D. and W. Henderson and Co., Meadowside, Partick, have secured three new contracts as follow:—One is a cargo steamer of about 8,000 tons deadweight for Messrs. Maclay and McIntyre, Glasgow, while the others are two cargo steamers for the Southern Railway Company. These latter vessels are to be similar to the two steamers Tonbridge and Minster, which Messrs. D. and W. Henderson built recently for the same owners. Messrs. Harland and Wolff, Govan, have received orders from Messrs. Elder, Dempster and Co. to build six barges for employment on the firm's West African manganese-ore trade.

BULLETIN OF THE ASSOCIATION TECHNIQUE MARITIME ET AERONAUTIQUE—The 28th bulletin of this important French Association, which has just been issued, contain a full report of the Session held in June last reprinting the papers in full, together with the discussions on them. The papers relate to naval architecture and marine engineering as applied to warships and merchant vessels, and several of them deal with aeronautical subjects. A report of the last general meeting of the Association is also given. The volume is obtainable from the offices of the Association, 7, Rue de Madrid, Paris; price 64 francs, post free.

ALBUM OF BRITISH AIRCRAFT.—A recent special issue of our contemporary *The Aeroplane* takes the form of an album of illustrations of aircraft of the heavier-than-air type constructed by British manufacturers. Attractive photographs, representing the best products of each firm, have been reproduced by a photogravure process in order to show that the machines selected are of good appearance as well as of high efficiency. In most cases full-page illustrations, measuring 10 in. by 6½ in., are given, and the illustrations are usually accompanied by specifications and other explanatory matter. The album, which contains 64 pp., is published by the Aeroplane and General Publishing Company, Limited, 14, Bream's Buildings, London, E.C.4, and its price is 2*s.* 6*d.*

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 7 p.m., at Storey's Gate, S.W. 1. Informal Meeting. "Boiler House Control Apparatus," by Mr. R. S. Whipple. Monday, December 15, at 7 p.m., Graduates' Meeting. "Some Aspects of Works Management, with a View to Cutting Costs of Production," by Mr. E. Gordon Davies, B.Sc. Friday, December 19, at 6 p.m. General Meeting. Second Report of the Wire Ropes Research Committee.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W 1. "Fluid Transmission Gears," by Mr. H. G. Bouly. Friday, December 19, at 7.30 p.m. Lecture: "Aircraft in Japan—Preceded by a Few Experiences of the King's Cup Race, 1924," by Colonel the Master of Semphill.

THE INSTITUTION OF PRODUCTION ENGINEERS.—To-night at 7.30 p.m., at the Engineers' Club, Coventry Street, W. 1. "Heavy Machine Tools," by Mr. C. D. Andrew.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 13, at 2.30 p.m., in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. "The Choice of an Efficient Fan or Ventilator for a Mine," by Mr. Joseph Parker, B.Sc.; "The Application of Airscrews to Mine Ventilation," by Mr. F. A. Steart (communicated by Professor Henry Briggs, Ph.D., D.Sc.); "An Experimental Study of Fan Evasées," by Professor Henry Briggs, Ph.D., D.Sc., and Mr. J. N. Williamson, B.Sc.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 13, at 3 p.m., at the Royal Technical College, George-street, Glasgow. Discussion on (*a*) "Some Uses of Hydraulic Stowing," by Mr. Richard Kirkby; (*b*) "Some Problems of Indian Coal Mining," by Professor D. Penman, D.Sc.; (*c*) "Problems of Mechanical Coal Mining," by Mr. Sam Mavor; (*d*) "Experiments on the Flow of Air in Mines," by Professor D. Penman, D.Sc., and Mr. J. S. Penman, B.Sc.; (*e*) "Efficiency of Safety Lamps," by Messrs. James Cooper and D. Davidson.

THE BRITISH COLD STORAGE AND ICE ASSOCIATION.—Monday, December 15, at 5.30 p.m., at the Engineers' Club, Coventry-street, W. 1. "Heat Transmission," by Mr. A. G. Clausen.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, December 15, at 7.30 p.m., in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Main Drainage of the Heaton and Walker Districts of Newcastle-upon-Tyne," by Mr. P. G. Pattison.

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 15, at 7.30 p.m., at the Bradford Technical College. Lecture: "Water Purification," by Mr. H. W. Coulson.

THE INSTITUTE OF TRANSPORT.—Tuesday, December 16, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Lecture—"Considerations Affecting Running Costs of Modern Commercial Road Vehicles," by Mr. H. B. Osler.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 16, at 6 p.m., at Great George-street, S.W. 1. Ordinary Meeting. Paper to be submitted for discussion: "Report on the Measurement of the Pressure of the Wind on Structures," by Mr. Thomas Ernest Stanton, D.Sc., F.R.S., M.Inst.C.E. Wednesday, December 17, at 6 p.m. Students' Meeting. Paper: "Mangahao Hydro-Electric Power Station," by Mr. Harold Charles Reeves, B.Sc.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 16, at 7 p.m., at the Lighting Service Bureau, 15, Savoy-street, Strand, W.C. 2. "Further Particulars and Demonstrations of Recent Advances in Electric Lamps and Lighting Appliances, based on the Report presented at the Opening Meeting on November 18 (with Special Reference to Shop-Window Lighting)."

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, December 17, at 2.30 p.m., in the Physical Chemistry Theatre, University College, Gower-street, W.C. 1. Special General Meeting. To consider Revised Constitution and Rules. Ordinary Meeting. "Some Notes on Standard Burettes," by Mr. H. V. E. Renn. Discussion of: (*a*) "Alumina-Silica Minerals in Glasshouse Pots and Tank Blocks," by Mr. W. J. Rees, B.Sc., F.I.C.; (*b*) "The Present Position of the Glass Industry in North America," by Professor W. E. S. Turner, D.Sc.; (*c*) "A Striking Instance of Fireclay Corrosion through the Action of Saltcake," by Professor W. E. S. Turner, D.Sc.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 17, at 5 p.m., at 49, Cromwell-road, South Kensington, S.W. 7. "The Problem of Warm Polar Climates," by Mr. C. E. P. Brooks, M.Sc. "Winds and Temperature in a Dry Atmosphere," by Sir Napier Shaw, F.R.S.

THE NEWCOMEN SOCIETY.—Wednesday, December 17, at 5.30 p.m., in Prince Henry's Room, 17, Fleet-street, E.C. 4. "The Development of the Cylinder Boring Machine," by Mr. E. A. Forward.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, December 17, at 6 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C. 2. Lecture: "Photo-Electrics," by Mr. C. F. Elwell, M.I.E.E.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN, BIRMINGHAM AREA.—Wednesday, December 17, at 7.30 p.m., at the Queen's College, Paradise-street, Birmingham. Lecture: "The Design of High-Speed Alternating Current Generators," by Mr. W. Sharp.

THE INSTITUTION OF WELDING ENGINEERS.—Wednesday, December 17, at 8 p.m., at Caxton Hall, Westminster, S.W. 1. "Thermit Welding," by Mr. Cecil Leigh, F.I.C., and Mr. Alfred Scott, M.I.Mech.E.

THE INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Thursday, December 18, at 6 p.m., at the Chamber of Commerce, Birmingham. "Contract Arrangements for Laying Reinforced Concrete Foundations in Tilbury Housing Scheme," by Mr. A. Muir White.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 18, at 6 p.m., at Savoy Place, Victoria-embankment, W.C. 2. Ordinary Meeting. "Speeding up the Telegraphs: a Forecast of the New Telegraphy," by Mr. Donald Murray.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 19, at 7.30 p.m., at Bolbec Hall, Newcastle-upon-Tyne. "Theory of Longitudinal Bending of Ships," by Mr. J. Lockwood Taylor, B.Sc.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—To-day it was definitely announced on the Cardiff Coal Exchange that the Egyptian State Railways had allocated their orders for the delivery of 200,000 tons of Monmouthshire and second Admiralty large coals delivered c.i.f. at Alexandria over the first five months of next year. The order has been split up between two firms, Messrs. Watts Watts & Co. Limited, Cardiff, securing 150,000 tons at 34*s.* 11*d.* and Messrs. Wm. Milburn and Co., Newcastle, 50,000 tons at 34*s.* 8*d.* Meanwhile the coal market generally has developed a steadier feeling and some of the idle pits have been restarted. Contractors are lifting the balances of this year's contracts with the result that the quantity of coal coming on to the market has been restricted, and salesmen have been able to hold out more firmly for their prices which are on the basis of 27*s.* 6*d.* to 28*s.* for best Admiralty large, 23*s.* to 25*s.* for Monmouthshires and 12*s.* and 17*s.* for smalls, according to quality. Official returns have now been issued by the Mines Department of the Board of Trade relating to the output, cost of production, proceeds and profits of the mining industry in the quarter ended June last. The return is of particular interest as it includes two months working under the new wages agreement which has resulted in the closing down of so many pits. So far as South Wales is concerned it is shown that the output was reduced from 12,444,480 tons in the first quarter of this year to 11,546,880 tons in the second quarter, and that the quantity commercially disposed of was lowered from 12,430,106 tons to 11,364,946 tons. The average price secured was also reduced from 21*s.* 10·66*d.* per ton to 21*s.* 5·83*d.*, but the net cost of production was increased from 19*s.* 8·42*d.* per ton to 20*s.* 11·38*d.* which resulted in a reduction in profits from 2*s.* 2·24*d.* to 6·45*d.* per ton. The following comparison of production in the two quarters will be interesting:—

	Quarter ended March. Per ton.		Quarter ended June. Per ton.	
	s.	*d.*	*s.*	*d.*
Wages	13	2·59	14	4·18
Stores, etc.	2	9·85	2	10·21
Management, salaries, repairs, etc.	3	0·49	3	1·56
Welfare Fund	0	1·10	0	1·09
Royalties	0	8·82	0	8·45

The number of persons employed was reduced from 225,464 to 221,580, and the shifts worked from 15,377,131 to 14,473,659, while those lost, which could have been worked, were lowered from 1,336,438 to 1,184,765. The output per man per shift was reduced from 16·19 cwts. to 15·96 cwts. and the earnings increased from 9*s.* 9·14*d.* per ton to 10*s.* 5·84*d.*

Iron and Steel Trades.—Exports of iron and steel goods from South Wales were reduced from 15,628 tons to 13,781 tons in the past week. Of the total, tinplates amounted to 5,127 tons against 9,111 tons, blackplates and sheets to 3,377 tons against 2,267 tons, galvanized sheets to 2,132 tons against 3,055 tons, and other iron and steel goods to 3,145 tons against 1,195 tons. The question as to whether the tinplate stabilisation scheme is to be continued for another twelve months is to be discussed by tinplate manufacturers this week. The minimum price of tinplates at present is 23*s.* 6*d.* per box.

POWER ALCOHOL FROM SUGAR BEET.—We understand that a deputation from the British Power Alcohol Association, a body affiliated to the British Empire Producers' Association, has been received by the Minister of Agriculture. The deputation urged that the proposed subsidy of 19*s.* 6*d.* per cwt. on sugar produced from beet grown in this country, should be extended to the sugar content of beet used for the production of power alcohol, the chief points made being the importance of the beet crop to the agricultural industry and the need for an alternative to petrol as a motor fuel. It was pointed out that foreign countries were initiating large schemes for the development of power alcohol, the United States being included among the number in spite of the fact that the largest supplies of petrol were in the possession of that country. Expert opinion was also quoted to the effect that if the cost for beet were just sufficient to make the sugar industry pay its way at the present price for sugar, power alcohol could easily compete with petrol at the average post-war price. It was suggested, however, that the diminution of supplies, coupled with the anticipated increase in demand, was likely to lead to higher prices for petrol in the future.

HAULAGE ENGINE FOR THE PENANG HILLS RAILWAY.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page* 789.)

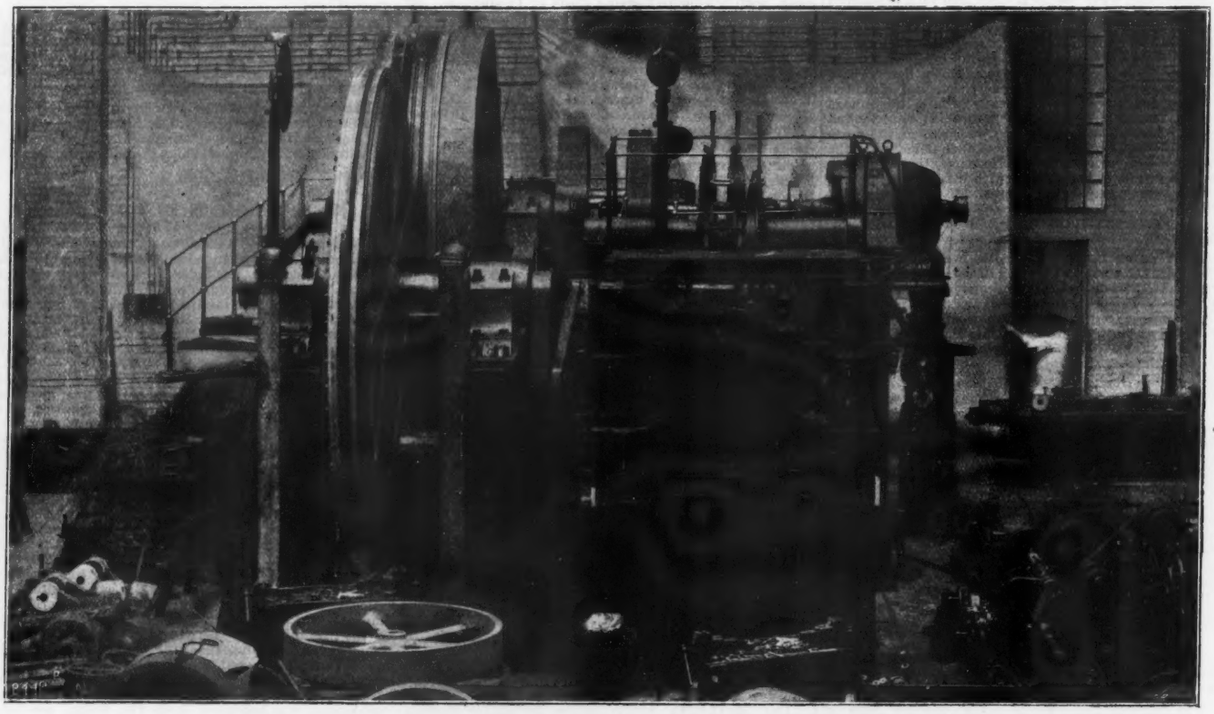


Fig. 77. View from Counter-Sheave End.

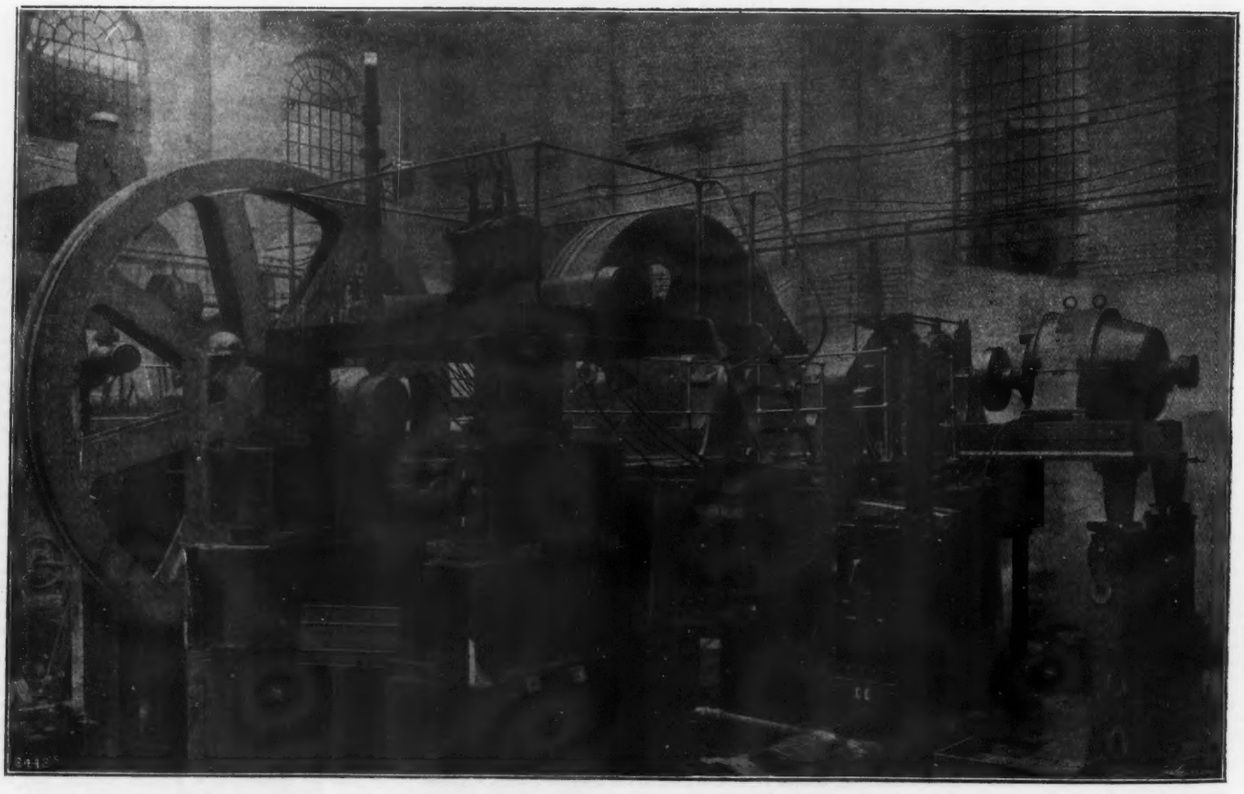


Fig. 78. View from Driving Platform Side.

2-8-8-2-TYPE SIMPLE ARTICULATED LOCOMOTIVE FOR

CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY, EN

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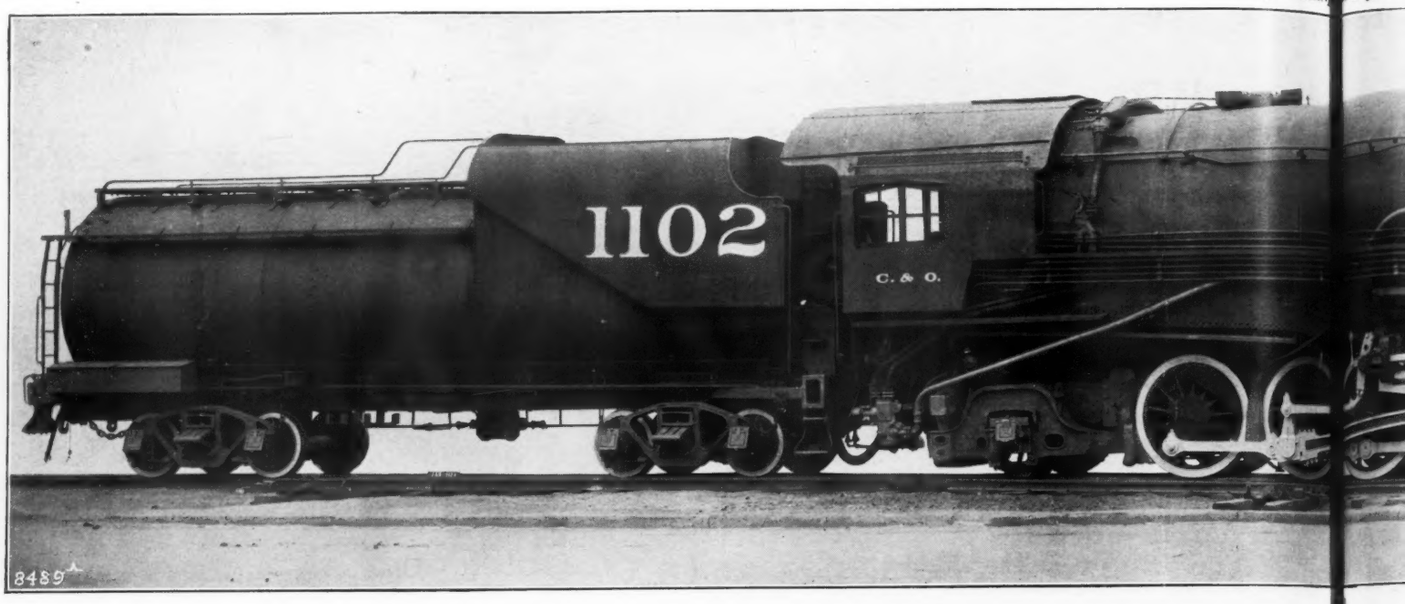


Fig. 2.

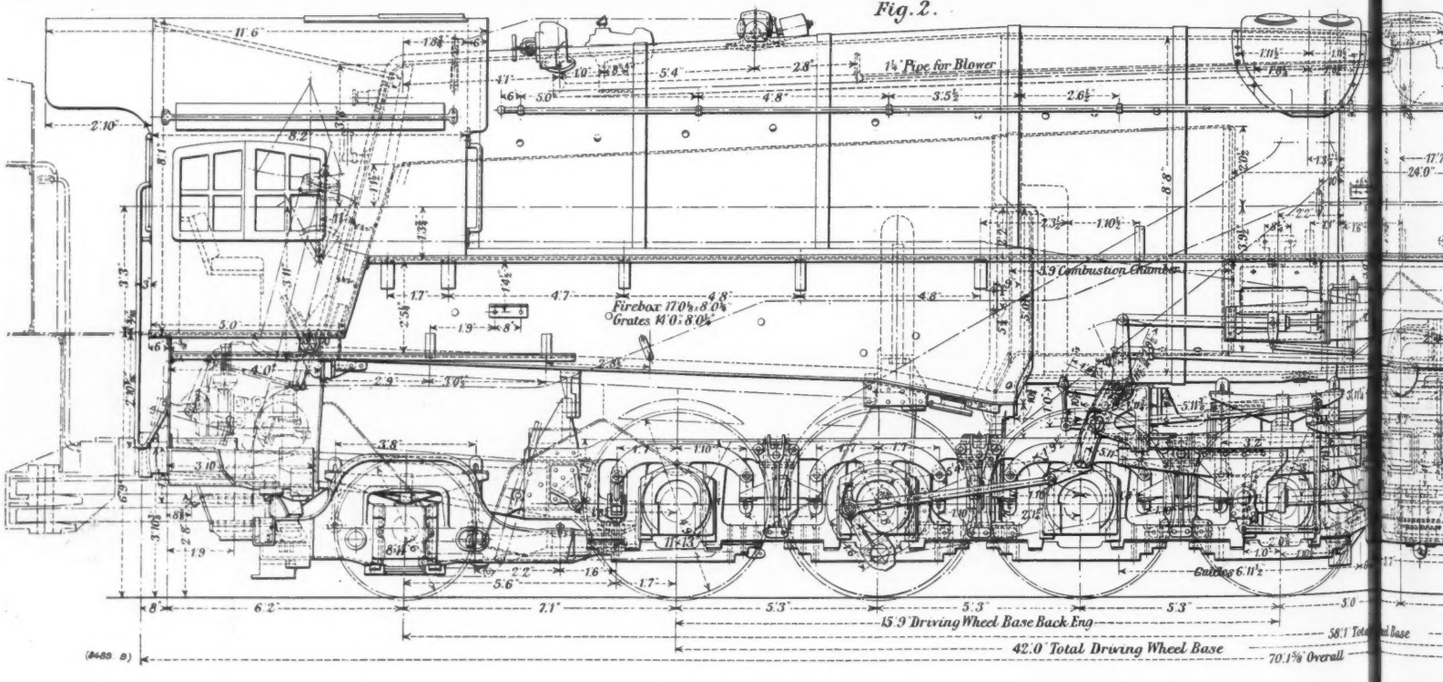


Fig. 4.

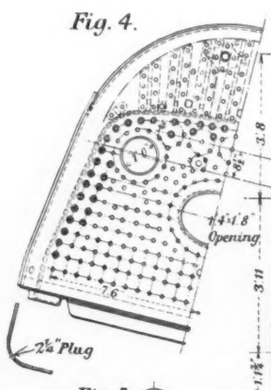


Fig. 5.

Fig. 3.

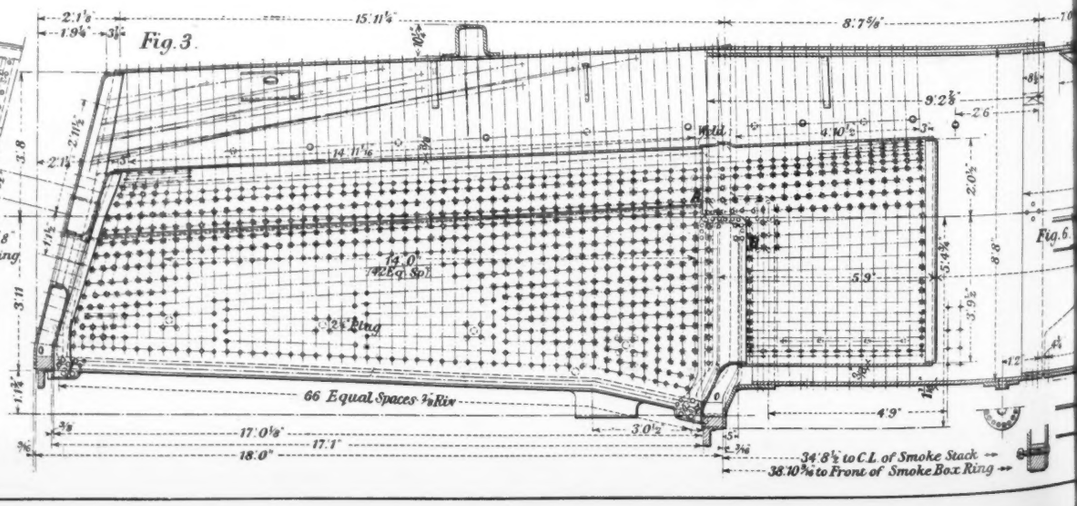
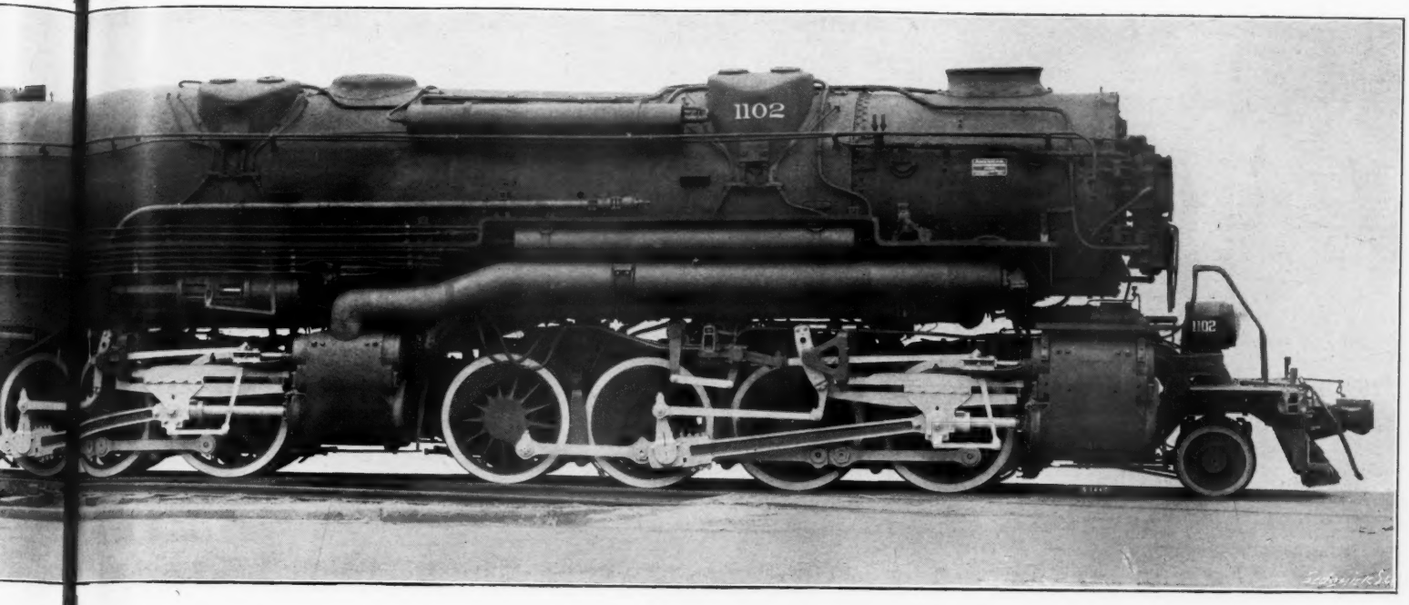


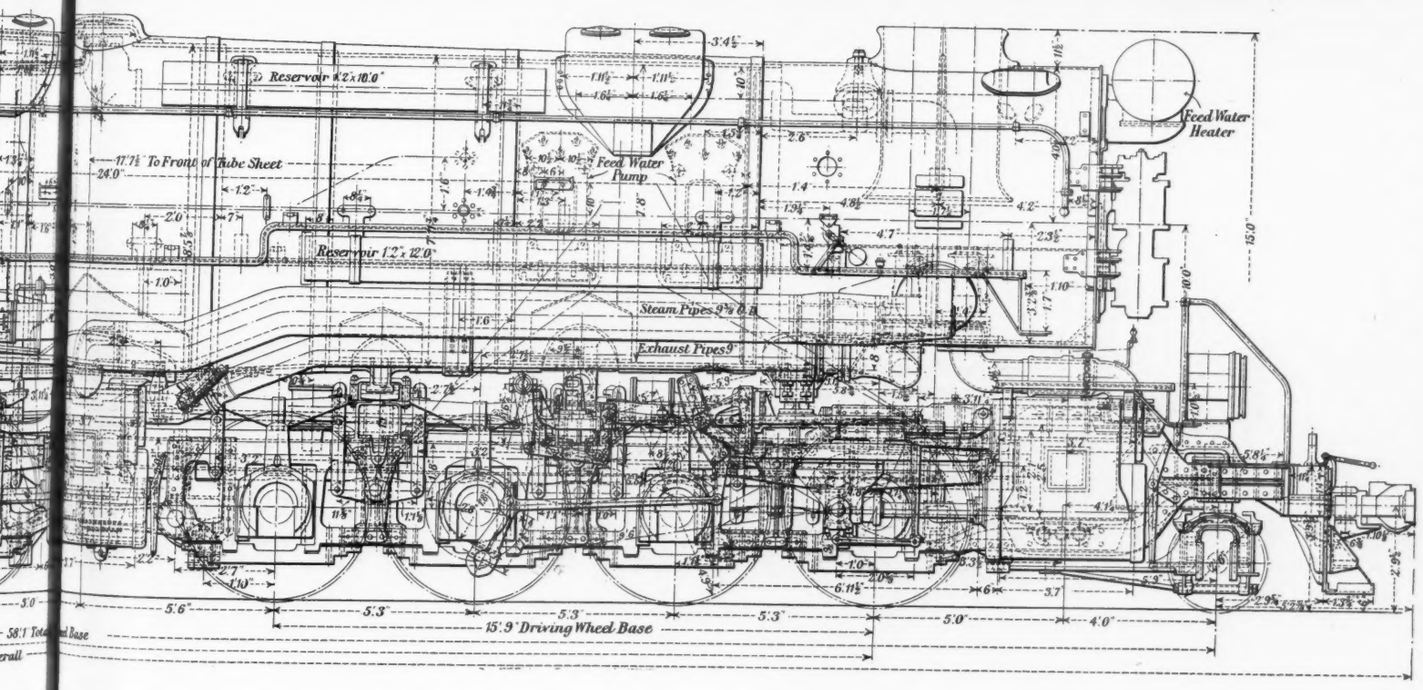
Fig. 6.

OTIVE FOR THE CHESAPEAKE AND OHIO RAILROAD.

OCOMOTIVE [illegible]ANY, ENGINEERS, SCHENECTADY, N.Y., U.S.A.

(For Description, Page 795.)





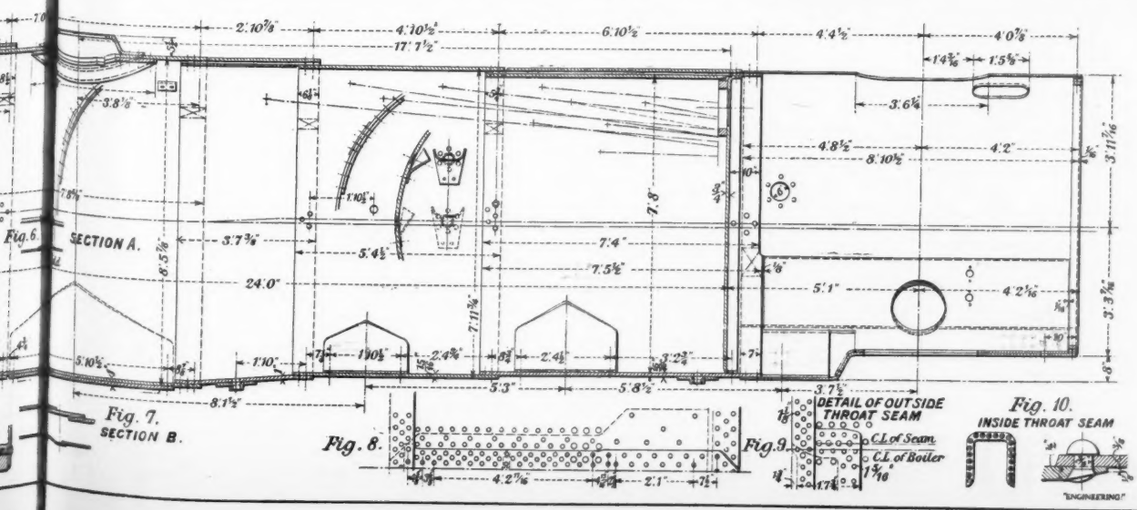


Fig. 6.

Fig. 7.
SECTION B.

Fig. 8.

Fig. 9.

Fig. 10.

"ENGINEERING"

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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Thick paper copies	£3	3	0
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Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son, Limited.

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Two-Page Plate.—2-8-8-2 *TYPE SIMPLE ARTICULATED LOCOMOTIVE FOR THE CHESAPEAKE AND OHIO RAILROAD*

ENGINEERING.

FRIDAY, DECEMBER 12, 1924.

MOTOR VEHICLE SUSPENSION SYSTEMS.

EVERY branch of engineering work has problems peculiar to itself, and in the case of automobile engineering one of the most difficult of these is the question of suspension. The factors involved in a solution of this question are exceptionally complex, and can never be completely expressed mathematically, since one of the fundamental elements—the form of the road surface, is infinitely variable. Even though it were possible to obtain a mathematical expression to cover the more commonly occurring road faults, such as an isolated pot hole or an approximately regular wave formation, the normal suspension system of a car is so complex that an equation expressing all the variables takes the form of a bi-quadratic with four imaginary roots. It has been found by a system of trial and error that the most satisfactory suspension is a system containing either two or three vibratory elements with a single resultant periodicity. In the simplest case the car body is mounted on two springs in series, the tyre and the spring proper, at each end, and if the car is fitted with a shock absorber of the helical spring type in addition, the rear suspension consists of three springs in series. Of these, only the shock absorber spring gives rise to simple harmonic motion, as both the leaf springs and tyres contain a damping element, and additional dampers, in the form of friction shock absorbers, are frequently fitted to both the front and rear springs. Finally, if the problem is considered from the point of view of the passenger rather than the body, a still further complication is introduced by the springs contained within the cushions. It is not surprising that under these circumstances car designers have preferred to arrive at spring and tyre proportions by a system of trial and error rather than by attempting to reach the correct dimensions by calculation, and it is not casting any reflection on such designers if we state that very few of them would be capable of following the mathematical consideration of the simplest case that could be stated.

Although it is clear that the final solution must always come from the experimenter in such a case as this, it is a mistake to assume that no good result can ensue from mathematical investigation, as the latter may frequently serve as a broad guide to the direction in which experimental work may be carried out to the greatest advantage. The most profitable results are likely to ensue from a sympathetic liaison between the mathematician and the experimenter. There are two ways in which a mathematical problem which is incapable of complete solution may be dealt with, the first being to make certain assumptions which render the problem as a whole amenable to treatment, while the second is to deal more completely with each part of the question separately, without attempting to retain the mutual dependency of the various factors. Both these methods are capable of yielding useful results so long as it is realised that the solutions are subject to the same limitations as the original statement of the problem. The advantages of mathematical investigation within recognised limits is clearly brought out in two papers which have been read recently before the Institution of Automobile Engineers. The first of these, entitled "Principles of Vehicle Suspension," was read by Mr. H. S. Rowell last session, and in this paper the suspension system is considered as a whole. The assumptions that are made to simplify the mathematical treatment are clearly stated, and there is no doubt that the results obtained, if given the reasonable interpretation that we have suggested, will be of considerable service to the designer. The second paper to which we have referred is that read last Tuesday by Mr. A. Healey on "The Tyre as part of the Suspension System," and this paper offers an example of the more complete investigation of one particular part of the suspension problem. Particular attention has been directed to the tyre problem recently by the extensive adoption of balloon in place of high pressure tyres, and the reasons underlying the change over are little understood, either by the motoring public in general, or by engineers in particular. Mr. Healey's paper thus appears at an opportune moment. Apart from a consideration of the tyre as a unit in the suspension system, the author throws an interesting light on several considerations arising in relation to the tyres, and makes a number of important deductions which should be helpful alike to the designer and to the user. The reason for the superior tractive qualities of low pressure tyres is clearly explained, and that for the superiority of a broken tread over a plain one on a surface which is liable to produce skids, is also dealt with. Among other very practical deductions, it is shown that unless the low pressure air in the case of a balloon tyre is confined in an appropriately small casing it has no advantage over high pressure air, and that it is quite futile to change over to a larger tyre and depend on the lower inflation pressure (*per se*) to give additional comfort.

The average motorist is mainly interested in the tyre question from the point of view of comfort, and assuming that he can obtain an improvement in this respect by changing his existing tyres for others, he is interested in knowing what relation the increased comfort obtained will bear to his running costs. The question of the form of motion which constitutes comfort or otherwise is one for the physiologist, and it is doubtful whether such a conception can ever be expressed in mathematical terms, as it appears not only to vary with the individual, but also to some extent to be a matter of usage in any particular case. As an example, it is generally found that when a person has become used to any particular driving position, he feels that all other positions are relatively uncomfortable. There is fairly general agreement, however, that, as regards imposed motions, the two main sources of discomfort in a car arise from anything in the nature of jarring, or of pitching with a frequency either above or below fairly well-defined limits.

Mr. Healey deals with both these points in some detail, and this will no doubt be regarded by many as the most interesting part of his paper for the reasons that we have already stated. Jarring is defined as a momentarily high acceleration, independent of the amplitude of the movement, and this definition is generally accepted within the limits of the movements imposed upon a person riding in a vehicle. Two sets of curves are given in the paper showing the actual vertical movement of a car body when being driven over a transverse rut in an otherwise good road surface, the records being obtained with an instrument of the seismograph type. The two sets of curves were taken on a vehicle fitted with ordinary and balloon tyres respectively, and bring out the striking result that whereas the actual displacement was approximately twice as great with the low pressure tyres, the acceleration was approximately half that obtained with the ordinary tyres.

As we have already stated, it is extremely difficult, if not actually impossible, to determine the natural period of a car body from theoretical considerations, as it is in this investigation that natural frequencies and damping factors of all the units in the suspensiou system enter. Fortunately, the actual determination of the pitching period in any given case offers no difficulties, and the effect on this period, of substituting low pressure for ordinary tyres, can be studied from actual examples. The general effect of the larger tyres is to lower the period of vibration, and this may have the effect of either increasing or decreasing comfort, depending upon whether the natural period of vibration in the case of the original tyres was near to the maximum or to the minimum limit of comfort. The author points out a further interesting effect that results from the change of tyre. When the car body is pitching the axle is executing a corresponding vibration of smaller amplitude, and the effect of the softer tyres will be to increase the axle movement and to reduce the spring deflection. As the damping coefficient is much larger in the case of the springs than in that of the tyres, the damping effect as a whole is reduced, and the pitching perseveres for a longer period.

The question of the relative economy of balloon and high pressure tyres is not dealt with in the paper, and it is probable that it can only be deduced as a result of extended experience of the two types. The author quotes experimental results showing that the low pressure tyre consumes more power on both rough and smooth roads, but this is only one item in the comparison of costs. Others are the relative first cost of the tyres themselves, the life of the two types, and the probable reduction in maintenance charges of mechanical parts due to the reduction in the inertia forces to which they are subject.

IRON AND STEEL SCRAP.

The working up of scrap in open-hearth steel manufacture dates from the introduction of the open-hearth furnace. It started first in the acid type of furnace, about fifty years ago, and has continued since to form an important proportion of the charge of the basic furnace also, one main difference being, as is well known, the latitude given in the percentage of phosphorus in the material forming the original charge in the basic furnace. Since scrap has formed from the very commencement one of the essential elements in the making up of an open-hearth furnace charge, it is somewhat surprising to find that there should be any necessity for a reminder to the effect that "scrap is not just scrap, but a by-product of the several manufacturing industries and of the country as a whole. As such, it should be properly 'fractionated' and sent to its appropriate reservoir."

The statement we have here quoted is contained in a paper on "Iron and Steel Scrap," by Mr. E. J. Lowry, read before the American Iron and Steel Institute, at New York, on October 24. The paper sets forth in detail the evils attendant upon the indiscriminate use of scrap. Amongst the evils to which attention is drawn are those traceable to sulphur, an element which is liable to be added to the metallic bath following the use of scrapped boiler tubes having lime and sulphate incrustations, or motor-car tyre rims to which parts of the rubber tyre fabric still adheres. Steel scrap containing chromium, nickel, copper and other alloys leads to increased cost in working the heat, or produces red shortness, or, again, gives a poor finishing surface to the steel produced. Further, scrap heavily rusted, or burnt scrap is not an economical material to use, dirty scrap also adds to the cost of steel manufacture. Galvanised and tinned scrap causes trouble in other directions. Such are some of the prejudicial effects which follow the use of the wrong class of scrap, or of inferior scrap, in the open-hearth furnace, and one object of Mr. Lowry's paper is to "enlighten the consumer, the producer and the seller of iron and steel scrap" in this matter.

Another statement of the author's is to the effect that the largest proportion of the scrap used for the making of new steel proceeds from the steel mills themselves; the scrap difficulty alluded to is, therefore, not one which concerns those mills in any way. The figures the author gives in this connection are interesting to record. The total annual tonnage of scrap produced in the United States, taking ten-year averages, amounts to 25,000,000 tons; of this quantity, 13,000,000 tons remain within the confines of the steel mills themselves for remelting purposes, whilst 12,000,000 tons, consisting of railway, industrial, motor-car and country scrap, with a relatively small quantity of imported material, constitute the quantity which appears annually on the market.

The major part of the alloy steel scrap available for sale may be said to be of greater value than the ordinary run of steel scrap, and dealers are most probably sufficiently aware of the higher price it commands to set it apart to be disposed of to advantage. In regard to the highly-corroded scrap and that which contains extraneous substances, such as sand, earth or cement, this is frequently met with in deliveries of old railway material, pot sleepers, tramway rails, &c. When this class of scrap is offered the dealer generally stipulates that he will listen to no complaint concerning it when once the sale is effected, a stipulation which implies, as a matter of course, that the scrap is not above suspicion from the point of view of its cleanness, and one that should act as a warning to the prospective purchaser. In practice, information as to the purity of scrap is not always essential to the seller. The consumer, in other words, the steel-maker, can be trusted to use the right article. The risk, as far as he is concerned, lies in the possibility of a proportion of unsuitable material finding its way into a charge, but in well-conducted steelworks this risk is generally negligible. In regard to the producer, if his industries yield as a by-product iron, ordinary steel, and alloy steel scrap, he can be relied upon so to "fractionate" it that he may obtain for the better sort the higher price quoted in the market.

One of the objects of the paper is to advocate a new and more concrete specification covering the different grades of scrap utilised in the steel and iron industries of the United States, since the specifications now in force no longer meet present-day requirements. It is difficult for us to enter into this question of classification as it appears to apply to that country's practice exclusively. Its main object is an economical one, to point out that "the increasing use of scrap in the iron and steel industry promotes the conservation of our natural resources; every ton of scrap utilised in the manufacture of steel saves for posterity a definite amount of raw material which will remain as our legacy to future generations." The 25,000,000 tons of scrap shown anbe available in the United States per annum, calculated on ten years' averages, do not appear to include any old warship scrap; the author throughout his paper makes no mention of this important "source"; it would yield scrap of a high quality, and clean, while a proportion of it would be directly serviceable without remelting. Several of these warships have been sunk at sea in target practice or otherwise, instead of being broken up.

A very serious loss to the industry of the whole world is that connected with the tinplate industry. The manufacture of tinplate year by year for use in food preservation alone absorbs an amount of steel which in some instances is comparable with and in others superior to that consumed in steel products which are very much heavier, indeed, per unit article. Practically the whole of this tinplate is valueless when once it has served its original purpose; both the tin used in its manufacture and the steel sheet become waste material. When an economical means of effectively dealing with all this material is forthcoming, the resultant saving will be found to be out of all proportion to the seeming insignificance of the articles thus salved for further utilisation. Unfortunately, tinned scrap, of which there is such an abundance, cannot be utilised as such in the open-hearth furnace, the tin affecting the qualities of the steel, as stated by the author. Even a certain amount of de-tinned scrap has a deleterious effect on steel, as was pointed out by Messrs. Whiteley and Braithwaite in a paper they recently read before the Iron and Steel Institute. In this connection at least the scrap problem is a very complicated one.

THE ITALIAN NAVAL MANŒUVRES.

It has only recently been possible to collect details of the naval manœuvres which were carried out in the Central Mediterranean by the Italian Navy, during the autumn of this year. The strategical problem was to test how far communications could be maintained between Italy and North Africa, in the teeth of opposition from an opponent roughly equal in strength. The details were as follows: An attacking, or red, force, consisting of two battleships, three light cruisers, thirteen destroyers and about six submarines was assembled at Port Empedocle, in Southern Sicily; a defending force, of practically the same strength, though weaker in destroyers and submarines, was assembled at Port Augusta, and a convoy of six merchant vessels was collected at Tobruk in Cyrenaica. The business of the "blue" force, under Admiral Lovatelli, was to meet the convoy, and bring it safely to Syracuse; and of the "red" force, under Admiral Conz, to stop them from doing so.

The manœuvres started at midnight on August 21; and the opposing Admirals made the following dispositions: (1) Admiral Lovatelli ordered the convoy to leave as soon as manœuvres began, and to steer for 300 miles in the direction of Zante. He arranged that it should be met at sea, during the 21st, by a flotilla leader and four destroyers; and, during the following day, by himself and the battleships. Admiral Lovatelli posted one detachment of submarines off Zante, with orders to attack all vessels which attempted to use the west coast of Greece for re-fuelling; and another in the Malta channel, with orders to attack his opponent as he took his fleet through it. (2) Admiral Conz detached one submarine off Tobruk—the convoy's port of departure—placed a light cruiser between Crete and Cape Matapan, to report the convoy if it made a *détour* round Eastern Crete; and sent a division of destroyers to patrol south of Malta.

Both admirals sailed as soon as the manœuvres began: Admiral Lovatelli for his convoy rendezvous: Admiral Conz for a point about 100 miles to the north-west of Benghazi. The movements of the "blue" fleet and its convoy were simply those of the original plan: the junction was effected at 10 a.m. on the 22nd at the point selected; after which the force steered north-west towards Zante until 8 p.m., and then made for Syracuse, which it reached on the 25th. It remains to be seen how Admiral Conz missed the objective assigned to him.

The submarine off Tobruk sighted the convoy when it sailed, and after dogging it for some way, reported its course and speed during the early hours of the 22nd to Admiral Conz, who was then some two hundred miles to the south-east of Malta. He continued his course towards Benghazi until the report was confirmed and, at 8 o'clock, being convinced that it was making towards Taranto, turned to the north-eastwards to cut it off. In this he was nearly successful, for he passed very close astern of it during the night of the 22nd, about twelve hours after it had joined up with Admiral Lovatelli; and about two hours after it had turned westwards for Syracuse. Admiral Conz was, however, unaware of his opponent's presence and held on for Zante where he fuelled. His fleet was, however, so harassed by the sub-

submarines which Admiral Lovatelli had placed there that he got under way again at 8 a.m. on the 23rd, and divided his fleet over three lines of search spread out towards the gulf of Taranto. Naturally, these detachments found nothing, as the "blue" fleet was making for Syracuse. Admiral Lovatelli reached Syracuse during the early morning of the 25th; but not without loss; for 10 miles off the harbour mouth one of his battleships was successfully attacked by a submarine. The result of these exercises was, therefore, that communication was successfully maintained between Southern Italy and North Africa and that the attempt to disturb it failed. Can it, however, be said, that the manœuvres prove absolutely that Italy's sea communications with the eastern Mediterranean are secure against an attack from an adversary of approximately equal strength? Hardly; and for the following reasons.

The supposition behind the exercises was obviously that France and Italy were at war; and that Italy was attempting to keep her communications with the Black Sea and Suez open. Now if these two countries were actually at war, it is probable that Italy would be able to get coal and iron from Central Europe across her land frontiers; but her supplies of oil and corn from Southern Russia and Rumania, would have to be carried in convoys sailing at regular intervals. It would be quite impossible for either side to protect, or attack, the weekly convoys from the eastern Mediterranean with their whole naval forces; and the operations would of necessity be carried out on quite a different plan from the one which formed the basis of the recent manœuvres. The French would obviously try to maintain very strong cordons of submarines in the Greek islands and to the south of Crete; and would reinforce them at critical times by cruiser raids. The main fleets could hardly be expected to put to sea every time an Italian convoy sailed. If, therefore, the Italian staff had wished to devise an exercise which really represented the strategical problem of defending the country's overseas supplies, they should have given Admiral Lovatelli the duty of protecting at least four convoys sailing successively, and at regular intervals from more than one neutral harbour. A spasmodic operation like the one described predicates a return to eighteenth century conditions, when convoys sailed once or twice a year. Modern commerce is fluid, and perpetually moving; and methods of defending and attacking oceanic trade routes have altered accordingly.

THE SMITHFIELD SHOW.

THE Smithfield Club Show, which is popularly associated with the exhibition of the fat cattle dedicated to Christmas festivities, has also been for many years a recognised occasion for the display of agricultural machinery and implements. It is well that this should be so because, not only do the manufacturers bring their products under the eyes of practical agriculturalists, but an opportunity at the same time is offered to the merchants and exporters of the Metropolis to inspect the various machines with the least expenditure of time and trouble. The show, which opened last Monday at the Royal Agricultural Hall, Islington, and closes to-day, is the 124th of the series, and differs in no essential respect from the Smithfield Shows of many years past. The cattle, sheep and pigs change as individuals, but the types remain, and the same is largely true of the machinery exhibits. Certain tendencies of agricultural machinery have, however, been noticeable for some years, and it is possible that a direct comparison of the exhibits at Islington this year with those of ten or twenty years ago would show a greater difference than might at first be thought to exist.

The time is not long past when the portable steam engine, consisting of a horizontal open type engine, mounted on a locomotive boiler on wheels, was the universal source of power for such farmers as had their own thrashing tackle. When such tackle was hired, as it usually was, the motive power was supplied by a traction engine, which also served to haul the thrashing machine, elevator, &c., from farm to farm. The traction engine persists, and many examples were to be seen at Islington, notably on the stands of Messrs. Marshall Sons and Co., Limited, Chas. Burrell and Sons, Limited, Wallis and Stevens, Limited, Clayton and Shuttleworth, Limited, William Foster and Co., Limited, and other well-known makers of this class of plant, but the portable steam engine of the old type seems to have completely vanished. A likely successor to it, in so far as the encroachment of the internal-combustion engine leaves room for agricultural steam plant, is to be found in the 20–35 brake horse-power portable engine of the Sentinel Wagon Works, Limited, of Shrewsbury. This is a combination of the vertical boiler of the company with a totally-enclosed steam engine, both constituents being similar to those employed on the well-known Sentinel steam wagons. The parts are mounted on a channel frame with wheels, so that the plant can be hauled to where it is to be used. The firebox consists of a vertical steel cylinder with spiral grooves pressed in the sides. The tubes, which are all straight and similar, are arranged like the straight lines which can be drawn on the surface of a hyperboloid, their ends being expanded into the sides of the corrugations. The whole structure is strong, simple and rigid, the tubes can be easily inspected and cleaned when the firebox is withdrawn from the boiler shell, and no tube joints are exposed to the fire. A competing type of portable plant, employing an internal-combustion engine, was shown by Messrs. Marshall, Sons and Co., Limited, of Gainsborough. The engine used was of the firm's horizontal, two-stroke, hot-bulb design, rated at 16 brake horse-power. Any crude oil could serve as fuel and the whole plant was simple and robust.

Except for the two engines mentioned we did not notice any other portable engine, in the ordinary sense of the word, at the show. Messrs. Drummond Brothers, of Guildford, exhibited their "Willing Worker" oil engine arranged in portable form in combination with a saw for outdoor work, and several other firms showed small combination sets for pumping, &c., which were more or less portable, but the place of the simple prime mover of 20 to 30 brake horse-power on wheels, seems to have been largely taken by the agricultural tractor. This, however, has not been so much in favour during the last few years, as it was during the war when horses were dear to buy and to keep, and it may be that the portable engine, whether worked by steam or oil, will regain some of the ground which it has lost. There was not, we believe, a single example of a stationary steam engine at the show, but stationary oil engines of all sorts and sizes were to be seen. Messrs. Blackstone and Co., Limited, of Stamford, showed a very nice-looking, single-cylinder, horizontal engine of their cold-starting, spring-injection type, rated at 55 brake horse-power. We illustrated a similar engine in connection with the Wembley Exhibition, and described in detail the mechanism by which the fuel is injected in a manner entirely independent of the speed of the engine. Another large horizontal, cold-starting engine, rated at 42 brake horse-power, was shown by Messrs. Ruston and Hornsby, Limited, of Lincoln. This also was of the airless-injection type, and was guaranteed to start at once from the cold condition in any weather and to run on the cheapest fuel oils obtainable, with a consumption of about 0·42 lb. of fuel per brake horse-power-hour. Messrs. Tangyes, Limited, showed a 47 brake horse-power engine of the same general type, but with details, of course, of their own special design.

Of other types of fixed oil engine, the two-stroke hot-bulb type was represented by a vertical single-cylinder engine of 50 brake horse-power on the stand of Messrs. Marshall, Sons and Co., Limited, while a smaller horizontal engine working on the same system was shown by Messrs. Clayton and Shuttleworth, Limited, of Lincoln. The smaller engines to run on petrol or paraffin, or either, were too numerous for individual mention. It is pleasing to see that British makers appear to have gained a a predominant position in the market for the small hopper-type engines, producing a far more attractive article than the imported engines which held the field almost exclusively a few years ago. Messrs. Ruston and Hornsby, Limited, Messrs. Bamfords, Limited, of Uttoxeter, The Wolseley Sheep Shearing Machine Company, Limited, all showed such engines, and many other manufacturers have also developed the type. Messrs. Petters, Limited, of Yeovil, and Messrs. Boulton and Paul, Limited, of Norwich, also exhibited a selection of their small engines, combined in some cases with pumps, dynamos, &c., to make self-contained units.

Cable ploughing tackle was exhibited by Messrs. John Fowler and Co., Limited, and Messrs. J. and H. McLaren, Limited, both of Leeds. The latter firm showed a motor windlass for hauling the plough, while Messrs. Fowler showed both steam and motor tackle. It is generally recognised that where deep cultivation is necessary, especially where land has to be broken up on a large scale in new countries, the cable system is practically the only means of doing the work effectively. The Fowler motor tackle, with 70 brake horse-power engines, finds particular favour in countries where good water and fuel are not readily available, and also where local legislation handicaps the use of steam plant by requiring the employment of certificated engineers to have charge of steam boilers. Messrs. Fowler also showed one of their light four-furrow anti-balance ploughs with self-cleaning mouldboards and revolving knife coulters, suitable for working in conjunction with either of the cable engines referred to. This plough will cut four furrows 10 in. deep and 14 in. wide at each traverse. Other ploughs were to be found on the stands of Messrs. J. and F. Howard, Limited, of Bedford, Ransomes Sons and Jefferies, Limited, Ipswich, Ruston and Hornsby, Limited, S. C. Darby, Wickford, Essex, and others. Messrs. Ransomes, Sims and Jefferies, Limited, showed a new implement called a "grass rejuvenator." In general construction it bore a certain resemblance to a horse-hoe or cultivator, but the tines were replaced with flat metal shoes about 3 in. wide, with upturned fronts. Immediately behind each shoe was a knife coulter with adjustment for depth. The progress of the shoes would flatten down the grass and the coulter following would cut into the turf and presumably "rejuvenate" it by admitting air and moisture to the roots.

Windmills were exhibited by Messrs. John Wallis, Titt and Co., of Warminster, and E. and H. Roberts, Limited, of Stony Stratford. Refrigerating machinery was, as usual, shown in the entrance arcade, all the well-known firms in this line, such as Messrs. J. and E. Hall, Limited, of Dartford, John Kirkaldy, Limited, of 101, Leadenhall-street, E.C.3, Ernest West and Beynon, Limited, of Belvedere-road, S.E.1, and others. There was thus an ample variety of mechanical refrigeration plant for purchasers to select from, and an equal choice of cold storage chambers and other apparatus for the preservation of perishable foods.

THE REPAIR OF WATERLOO BRIDGE.

THE question of the best course to pursue with regard to the repair of Waterloo Bridge was considered by the London County Council on Tuesday last, when a report of the Special Committee on Thames Bridges was taken. The Special Committee report reviewed recent events which have had a bearing on the question, and especially referred to a deputation received by them, and representing the Society for the Protection of Ancient Buildings. This deputation laid great stress upon the national importance of preserving Rennie's bridge, and their engineer, Mr. H. H. Dalrymple-Hay, M.Inst.C.E., had put forward a scheme by which it was considered a "safe, permanent and economical remedy" was provided. In view of the widespread interest taken in the repair of the bridge and the preservation of its original character, the Special Committee deemed it advisable to secure some verdict which would command general assent, and to this end they suggested that the assistance of the Council of the Institution of Civil Engineers might be enlisted with a view to considering whether "it would be practicable and reasonable to underpin all, or some of the piers, so as to render the bridge permanently safe and to enable it to be restored to its original form."

A resolution from which the foregoing words are quoted was proposed at the Council meeting on Tuesday, and, on it being explained

that it would involve no delay, since the repairs cannot be undertaken before the completion of the temporary bridge next summer, the proposal was adopted. This step has been taken because to use the words of the report, the Council of the Institution "represents practically the whole of the engineering skill and experience in the country." Quite apart from an expression of opinion as to how the Council might deal with such a reference, it may not be out of place to point out that that body represents all branches of engineering, including, other than civil and construction work, for instance, electrical engineering, shipbuilding, &c., while two of its eminent members—Mr. Basil Mott, President, and the late Sir Maurice Fitzmaurice, a former President—have already, as engineers experienced in such works, placed their views before the Council in an official consultative capacity.

THE CARDIFF ENGINEERING EXHIBITION.

(*Concluded from page* 769.)

The Cardiff Engineering Exhibition, which closed on Saturday last, contained many examples of the various types of electrical appliances which are used extensively in the modern practice of mining. Trolleys and other current collectors for haulage locomotives were the outstanding examples on the stand of Messrs. Brecknell, Munro and Rogers, Limited, of Bristol. A spring-controlled pantograph-type of collector, suitable either for use in main-line electrification or for haulage locomotives, was shown, which attracted a great deal of attention because of its easy movement combined with the certainty of its continuous contact with the overhead wire. The Harland Engineering Company, Limited, of Manchester, and Messrs. J. H. Holmes & Co., of Newcastle-on-Tyne, showed various types of switchgear. One exhibit of the latter-mentioned firm consisted of a unit-type ironclad switchboard with bus-bar chamber and three feeders of different capacities, each having an interlocked switch and fuse. This switchboard was completely enclosed in a cast-iron casing having machine-faced joints, to ensure that it was flame-proof and therefore suitable for use in fiery mines. Another example of switchgear for mines on the same stand, was of the oil-switch draw-out type, with a no-load and three overload releases. In this equipment all the movements were interlocked to make it completely fool-proof. The live parts were enclosed in cast-iron or welded-steel casings, with effective joints to make them flameproof. Electric motors of both the alternating and direct-current types were also exhibited by the same firm.

The British Electric Plant Company, of Alloa, showed the application of their standard types of electric motors to pumping and to ventilation. Among the various examples shown there was a 22-h.p. squirrel-cage motor which was designed for duty under very damp or dusty conditions. Although totally enclosed, this motor had channels cut through the stator laminations through which air from outside was forced, to keep down the temperature. As the air used for cooling did not come into contact in any way with the electrical parts of the motor, the dangers that might otherwise be experienced were completely eliminated. Messrs. Blackstone and Co., Limited, of Stamford, in addition to the exhibition of their well-known oil engines of the cold-starting type, showed an unchokable pump driven by a "Bull" electric motor. This pump works on the centrifugal principle and has a wide impeller, so that it can pass fibrous solids, sacking and other such matter, which might occasionally be found in the water. To prevent the possibility of grit getting into the bearings, a water connection is provided to the neck-bush, in which water is run under pressure. When abrasive materials are suspended in the water the greatest wear takes place on the side walls, where the water leaves the impeller. At these points the metal of the pump is made very thick, and a renewable cut-water block made of steel is fitted, which is quickly and easily replaceable. The Uskside Engineering Company, Limited, of Newport, Mon., also showed pumping plant, their exhibit consisting of a three-throw ram pump with rams of 4½ in. diameter and 8-in. stroke. This was driven by a 9-h.p. motor made by the Electric Construction Company. In this pump the barrels and valve-boxes form a single casting, mounted on side frames of rolled steel. The slipper type of guider is fitted. The drive from the electric motor, which is also mounted on the side frames, is taken through two sets of spur gearing, one at each side of the frame, to the pump crankshaft.

Chain driving is now finding extended application in cases where large powers must be transmitted. For the purpose of demonstrating the movements of the components of their inverted tooth chain for this duty, Messrs. Hans Renold, Limited, of Burnage Works, Didsbury, Manchester, exhibited a chain designed to transmit 500 h.p., which was driven slowly by a small motor to facilitate examination. This chain had three strands, each of 7-inch width and ran on wheels of 17 teeth and 68 teeth at 6-feet centres. The Coventry Chain Company, Limited, of Coventry, showed many views of heavy chain drives in works and, in addition to displaying examples of the links of their many types, exhibited the use of chain drives in gear boxes for motor car and general engineering transmission systems.

Mining engineers have many problems to consider in connection with winding and haulage by ropes, especially in cases of inclined haulages where many unfortunate accidents have occurred. A type of wire rope for winding, which is rapidly gaining the appreciation of the mining public, is composed of strands of keystone formation, built up of a series of round wires. In this form of rope the triangular core is made up of circular wires which do not break up—a source of unseen weakness in earlier types—and the construction results in a very flexible rope. This type as well as many others, was exhibited by Messrs. John and Edwin Wright, Limited, of Birmingham. Locked coil ropes were shown, which are free from the tendency to spin and have a smooth outer surface. For the best types, the wires are not made up from layers alternately to the right and left throughout the rope, but have all the inner layers laid in one direction and the outer one only in the opposite way. Incline haulage ropes, as they frequently rub the floor or roof, are subjected to considerable wear. For this reason a high factor of safety must be used and Messrs. John and Edwin Wright, Limited, showed examples in which this is obtained by the adoption of a compound flattened triangular strand.

Stone dusting, to reduce the possibilities of coal-dust explosions, is a process which may be carried out cheaply and effectively if hand distribution is replaced by a mechanical process. Messrs. Oldham and Son, Limited, of Denton, Manchester, having recognised this, designed an automatic dusting machine which may be taken through any of the mine roadways, where rails are laid. It is provided with a sloping hopper made up of steel plate and welded. This is mounted above a fan and air pipe with nozzles, on a wheeled truck. As the machine is hauled along the roadways, motion is taken from the axles of the truck through chains and a gear box to the fan, which has a cast-aluminium impeller. The air passed from the fan meets the dust at the nozzle and throws it into the air, from which it falls in a very regular way, not only on the floor, but also on ledges. A reciprocating agitator, fitted with a special dust web, which prevents clogging, assists the motion of the stone dust to the nozzle. This agitator gets its motion from a crank and connecting rod mechanism from the second shaft of the gear train used for the drive to the fan. Provision is made to distribute dust when the machine is stationary by rotating a simple hand lever. A clutch in the transmission system makes possible the disconnection of the fan, and thus the machine may be moved about quite freely, from place to place in the mine, without distributing any dust.

For many years the subject of underground lighting has received consideration. A new outlook has been manifested since the perfection of the electric battery lamp, which is now in common use in many mines. The exhibition at Cardiff afforded an indication of what is now available to the mining engineer in this respect, for lamps of the Oldham, Ceag and Wolf types were shown by their makers. The provision of general lighting in a mine involves the consideration of many other problems. Armoured cables must be used for the distribution, because they are subjected to many possible injuries. Wiring with armoured cables usually involves the severing of the armouring at every point in the system. That this is a very undesirable thing, and introduces many possibilities of dangers, which the use of armoured cables was intended to avoid, will be readily seen by anyone who appreciates the conditions. It was for this reason that the Central Electrical Company (Nottingham), Limited, of 25, Clumber-street, Nottingham, introduced the system of fittings and wiring which is known as the Clifton continuity lighting system. By this method the armouring of the cables is preserved uncut, as well as the conductors. At the various fittings the armouring is pulled to each side, and each half is retained at the side of the plug by means of metal clamps which are held together by screws. The exposed insulation is then cut and the uncut conductors are taken through clamps to the plug at each side. In communication with these clamps are the plug connections. As the service fittings are adaptable for fuse, switch or lighting fittings, and are enclosed in a casing which is flame-proof, and to which the cover or plug fitting is held by a simple locking device, it will be appreciated that this continuity wiring has much to recommend its use.

Before closing our report on this Exhibition we should call attention to the lubrication problems which face the mining engineer. In collieries machines, whether on the surface or underground, work under conditions in which dangers arise from the presence of coal dust and other foreign matter. It is for that reason that the design of the lubrication system must be considered from the standpoint of providing for the total exclusion of anything which will impair the running. Not only are the conditions exceptional in this respect, but if efficiency is to be maintained, and economy in working obtained, the oils used must be selected with care. Messrs. W. B. Dick and Co., Limited, of 26, Grosvenor-gardens, London, showed by the exhibits on their stand that they appreciate the conditions, and have attained a great measure of success in the processes of blending to obtain a suitable lubricant for every specific purpose and service with mining plant.

Weldless tubes, shown by the British Mannesmann Tube Company, Limited, of Newport, Mon., in great variety, have now been introduced in the form of telescopic pit props and are finding growing popularity. Attention should also be directed to the successful work of Messrs. Edward Le Bas and Co. of Dock House, Billiter-street, London, in making malleable pipe fittings, 100 examples of which are shown connected together in the way they were when subjected to a test pressure of 3,000 lb. per square inch without any indications of leaks.

New Plans for British Industries Fair.—Owing to the proposed re-opening of the British Empire Exhibition, the Department of Overseas Trade has decided to suspend the London Section of the British Industries Fair until 1926, as a temporary measure. Arrangements have consequently been made by the Birmingham Chamber of Commerce to organise sections in their Fair for industries which have hitherto exhibited, and would ordinarily exhibit, in London, provided adequate support is secured. The British Industries Fair at Birmingham will be held from February 16 to 27, those dates having been chosen as most suitable by means of a referendum to the exhibitors themselves. Applications for space should be made at once to the General Manager, British Industries Fair, the Chamber of Commerce, 95 New Street, Birmingham.

James Watt's Workshop.—It is pleasing to note that Major Gibson Watt has presented to the Science Museum, South Kensington, the contents of the attic workshop of James Watt at Heathfield Hall, Handsworth, near Birmingham. The famous engineer lived here from 1768 until his death in 1819. Following this period the workshop remained closed for some forty years, after which it was shown to visitors from time to time. The estate on which it stands has now been sold and will be built on, so that the house will probably be pulled down. The museum authorities, however, are to reproduce the present attic and place the furniture and machine tools in it in the same position occupied in the Heathfield Hall room since the death of Watt. The room will be on the ground floor of the new museum building and will be near the two Boulton and Watt engines built in 1788 and 1797 at present preserved in the museum.

LITERATURE.

Brassey's Naval and Shipping Annual. Edited by Sir ALEXANDER RICHARDSON and ARCHIBALD HURD. 1925. London: William Clowes and Sons, Limited. [Price 25*s.* net.]

To a nation, whose first line of defence is its navy and which is dependent upon its export trade for the provision of food from overseas for its people, it is essential that accurate and authoritative statements should be readily available on the many vexed questions which are concerned. For thirty-six years "Brassey's Naval and Shipping Annual" has fulfilled the requirements on subjects of naval interest and has been extended to cover merchant shipping questions in the last few years. The new volume which has just been published shows the same characteristics of thoroughness in treatment of the various questions, on which the reputation of this standard reference book has been built up. Nothing comparable is elsewhere available, and, therefore, everyone who desires to be well-informed upon the vital questions of to-day, relating to the various navies or the merchant services, cannot neglect to peruse its contents and study the views of the many eminent authorities who contribute the various chapters.

The outstanding naval questions of the present time are the future of the light cruiser, in view of the provisions of the Washington Agreement, the relation of air power to sea power and the construction of naval bases to facilitate the protection of the distant parts of the Empire. On the mercantile marine side, there are many matters of importance that demand attention, such as the progress of the motorship, the reconstruction of the German mercantile marine and the united action of shipowners, and the trading community in discouraging acts of flag discrimination. On these and many other subjects, "Brassey's Annual" provides information in contributions by men of established reputation, in which the issues are studied from various angles, so that clear and accurate deductions may be based upon them.

The work, as has now become the usual practice, is divided into sections, of which the first deals with naval affairs. Commander C. N. Robinson, R.N., has contributed an important chapter to this section dealing with the "Naval Forces of the British Empire," which is a regular feature of the book, while Lieut.-Commander A. Colquhoun Bell, R.N., has provided an article on "Foreign Navies," and the editors, Sir Alexander Richardson and Mr. Archibald Hurd, discuss "Comparative Naval Strengths." It has been the contention of many leaders of public opinion outside the naval services as well as some naval authorities, that the only effect of the Washington Agreement has been that the great naval powers have given up the competitive building of capital ships and concentrated on the accelerated construction of light cruisers. Indeed, a chapter in this year's "Brassey's Annual" on the "New Light Cruiser Programmes of the Powers," by Captain Dudley W. Knox of the United States Navy, shows this outlook. In this article he says, "Whatever gains may have been made by the Washington Conference towards alleviating the burden of armaments, and allaying war-provoking international suspicions, is being rapidly lost through the great programmes of cruiser construction." That this view of the situation is not well founded is shown quite clearly by the editors, who discuss the programmes of the British Empire, the United States Japan, France and Italy. On the evidence available the deduction is based that in 1928 all the powers except Japan will be weaker in cruisers than they were ten years ago. The close examination of the information provided in the articles of Commanders Robinson and Colquhoun Bell confirms the views of the editors. From the statements already made it will be evident to all that "Brassey's Annual" does not provide merely the hide-bound views of any particular school of naval thought, but gives freely of the opinion of authorities, although they may be conflicting. American naval policy is discussed by Rear Admiral A. P. Niblack, U.S.N., while Sir George Thurston deals with the important subject of "Light Cruisers," and Capitaine A. Delpierre gives information on the same subject from a French standpoint, and contends that France should not build any more cruisers, but should concentrate on submarines and aircraft.

The co-operation of aircraft in naval operations is dealt with in two chapters, the first of which on "The Navy and its Fleet Air Arm" is unsigned, while the other is provided by Air Commodore E. A. D. Masterman, C.B., who discusses "The Commercial Airship as a Reserve for the Navy." In dealing with the relationship of the air fleet to naval vessels the author of the first article shows an intimate knowledge of the questions involved in the dual control of the two services, which must collaborate in times of war. Strong claims are made for the control by the Navy of its own air arm, in order that complete co-operation in any engagement, free from every form of misunderstanding may be obtained. The airship may prove to possess great advantages in travelling over vast ocean spaces for days at a time as compared with a cruiser, but for economic reasons it is almost imperative to look to the commercial airship to demonstrate this. It has been the aim of Air-Commodore Masterman to provide what information is available on these points and to formulate conclusions of great interest to the nation upon them.

The Navy cannot operate without bases, where necessary fuel and stores may be obtained, and where if necessary some types of repairs may be effected or replacements made, and it is essential that such bases should be available at places which serve in ensuring the safety of the wide spread components of the British Empire. The Singapore scheme has now been reconsidered, and it is intended to complete the originally contemplated base. At such a time as this when there are controversies on the question of distant naval bases it is refreshing to find such a valuable and comprehensive treatment as is found in the chapter by Commander C. H. N. James, R.N. The Naval section of "Brassey's Annual" is completed with an article on "A Well Balanced Fleet" contributed by Capt. E. Altham, C.B., and one on "The Naval Career" by Commander C. N. Robinson, R.N., in which full information is provided for those who intend to join the service.

Sir Westcott Abell contributes the first article in the Merchant Shipping Section, in which he discusses the economic position in the maritime countries, the decisions of the International Shipping Conference and the progress of merchant fleets. No more exhaustive presentations of the shipping and shipbuilding situations has so far been presented. The influences of the rebuilding of the German mercantile marine is discussed by Sir Westcott in this chapter, and another contribution of the same subject is provided by Dr. Leisler Kiep of the Hamburg-America Line. This is among the most important chapters in the book, as it gives, for the first time, an authoritative statement on what merchant ship developments are being made in Germany. The effect of state-owned vessels upon private shipping enterprise in the United States of America is clearly stated by Sir Westcott Abell, and will prove informative reading to all who are interested in sea-borne trade. That flag discrimination is a source of much trouble, and an obstacle to the development of overseas trade, cannot be gainsaid. A complete discussion of the questions involved is given in a contribution by Mr. Charles Tennyson, deputy chairman of the Federation of British Industries. Another trade restricting obstacle is presented by the limited facilities available at some British ports. Recently an investigation was conducted by the Chamber of Shipping, and the Chairman of the Committee, Sir Frederick Lewis, has provided an able exposition of their conclusions, which indicated that about 20,000,000*l.* was being spent to improve the ports.

The article on "Marine Machinery in 1924," by Mr. James Richardson, is naturally devoted almost entirely to the progress made with internal-combustion engines. In this contribution the new types of engines are referred to, and thus it serves as a useful indication of the trend of design. Mr. John Anderson examines recent proposals for the improvement in the equipment of merchant vessels dealing with the contra-propeller, the Flettner rudder, the Macgregor liquid brake for rudders, and the use of electro-hydraulic cranes in place of winches. Safety provisions and emergency appliances also receive attention among other matters in a well-written chapter. In many parts of the world it is necessary to transport goods and passengers in ships of shallow draught. That the design problems involved in the provision of suitable craft have been solved, is shown by examples of British construction chosen for reference by Mr. Charles Cooper in his able article on the subject. Wireless direction-finding is discussed from the point of view of practical results in a contribution by Captain H. F. Towler. Other chapters of the new edition deal with "Refrigeration," the "Port of Liverpool," contributed by Mr. Thomas Rome, and "The History and Work of The Worshipful Company of Shipwrights," by Mr. E. A. Ebblewhite.

The characteristic ship profiles and plans and statistical information, which are a valuable part of the book, have been brought thoroughly up to date. To say that this is merely a new edition of an old work would be completely erroneous, for "Brassey's Annual," with its distinctive features of treating every new development and providing information on naval and merchant shipping policy is, in truth, an absolutely new production every year. This volume, appearing at a period when many old ideas are giving place to new, is an essential reference book for all who are concerned in any way with questions relating to naval affairs, shipbuilding, shipping, marine engineering and general export trade.

Mechanical Road Transport. By C. G. CONRADI, M.I.Mech.E., London. Macdonald and Evans. [Price 21*s.* net.]

RECENT events have tended to bring home to the public that effective transport is vital to the nation's prosperity. The solution of the problem of improved facilities lies essentially with the engineer, but as effective measures in this direction involve the expenditure of large sums of public money, it is desirable that a knowledge of the problems involved should be as widely spread as possible.

In his book on "Mechanical Road Transport," Mr. C. G. Conradi has been successful in bringing together an astonishing amount of information on matters appertaining to all forms of road transport, and although the work has been compiled primarily for engineers, much of the information given should be read without difficulty by those whose technical knowledge is limited. In this connection we can fully endorse the conclusion given in a short foreword by Dr. Hele-Shaw to the effect that "the book is written in such an attractive manner and is so well illustrated throughout, that while it is pleasant and instructive reading for those who devote their whole time to road transport, it forms an excellent text book for younger men (and women) who are adopting this branch of engineering as their profession, or are embarking on the commercial side of the motor industry." It might be thought from this quotation that the book was rather in the nature of a popular treatise than a technical work, but it actually forms a happy combination of both. Even engineers who possess a fairly wide knowledge of the more technical side of transport will find a fund of useful information on the technique of design of various types of vehicle.

After a short historical review, the author deals in turn with roads and road resistance, horse traction, power required for traction, fuels, and a comparison of the types of motor vehicles available. Steam, petrol and electric vehicles are then described in some detail, and the work concludes with chapters on petrol-electric combinations, tramways and 'buses, special types of vehicles, loading and unloading devices, tyres, working costs, and driving instructions. A number of useful appendices are given comprising the various Acts governing motor traffic of all sorts, the comparative weight of materials commonly carried on industrial vehicles, a list of British Standard Specifications and Reports applicable to road traction engineering, and a list of Government publications relating to transport. It will thus be seen that apart from the more purely descriptive chapters relating to the various types of vehicle in use, the work as a whole forms a most valuable book of reference on all matters appertaining to transport.

Turning to the contents in rather more detail, it

was perhaps to be expected that in view of the author's unrivalled knowledge of electric vehicles, some bias would be noticeable in favour of this particular form of transport. If such a bias can be detected, we must admit that the case made out in this respect is entirely convincing. It is difficult to criticise when we have nothing but admiration for the exceptionally able way in which the author has presented a mass of information which in other hands might have become a tedious compendium of facts, but we feel that the chapter on roads might have been extended with advantage, and that if it was considered desirable to retain the book at its present length, a somewhat less detailed description of the ordinary petrol vehicle would have sufficed, as this information is very readily available elsewhere. The direct relation between the design of the road and that of the vehicle which it is intended to carry cannot be stressed too strongly, and progress is unduly retarded at the present time by the lack of co-ordination between those responsible for road construction and those responsible for vehicle design. As a result, we have the road designer constantly endeavouring to evolve a construction which will stand up to existing traffic conditions, of which advantage is immediately taken by the vehicle designer to introduce a heavier type of vehicle which will in its turn destroy the new surface. It would appear that a liaison is necessary similar to that existing between the permanent way and locomotive departments of a railway, where it is clearly recognised that a locomotive which will destroy the existing track, however efficient it may be as an isolated proposition, is uneconomical in the widest sense.

The chapter on the petrol-electric vehicle forms quite the most admirable treatment of this difficult subject that we have seen, but the advantage of this form of transmission from the point of view of increasing the ton-miles per gallon in certain cases deserves even stronger emphasis. We would advise readers of this portion of the book to also make themselves familiar with Mr. Murphy's paper on "The Misuse of the Internal Combustion Engine," which appears in the Proceedings of the Institution of Automobile Engineers for 1923–4.

Upon the whole the illustrations are excellent, but some of them, as, for example, the curves given in Chapter IV, might with advantage have been reproduced to a somewhat larger scale. As a final point we might mention that Fig. 32 is disfigured by some 172 part numbers to which no reference is made in the text.

LETTERS TO THE EDITOR.

"THE RISKS OF ACCIDENTS."

To the Editor of Engineering.

Sir,—Your recent comments on a particular statistical investigation into the Risk of Accidents are, I venture to think, not directed from the correct viewpoint. I do not propose to discuss this statistic other than to say that it is rather a short one of its kind (N = 116) and consequently weak.

Your criticism, and also in some degree that of your correspondent, Mr. Roper, appear to deplore that the various factors differentiating one worker from another are not taken sufficiently into account, and to require that all such factors shall be considered before the statistic (I use the word to include the mathematical analysis of the compilation) is made. This, however, is putting the cart before the horse. This form of statistic is precisely the same as those included in the generic name "chance." Now there is no such thing as chance when all the factors are known. Chance is a word which is used to comprise all the factors of an event which we agree to consider intangible. If we know, for instance, all the factors of and affecting a certain horse—all his anatomical and physiological equations, the effect of temperature, wind, colour, lighting, the noise of the crowd, the waving of a handkerchief, and a million or so internal and external factors, we should know precisely where he would be at a given moment in a given race. But we don't, and so men bet on the event. There is no absolute chance in tossing a penny if we know all the factors of the toss. Similarly, in physics and engineering we have "coefficients," the "probable" values of a thousand factors of which we are happily in ignorance, thus enabling us to use a simple formula instead of one which would fill a book and take a lifetime to apply.

So, in an investigation of accidents or any other statistical subject, the first thing to do is not so much to sort their figures into sub-classes, but to make a comprehensive survey. Having done this we discover either a tendency in some direction, or possibly a lack of any tendency. Some sorting is, of course, usually necessary, but this is primarily confined to the obviously known variables.

Now, the object of any statistical investigation, apart from it as a recreation, is to unmask tendencies, an operation which comes after and not before. For example, you published some years ago the approximate curve of chance on gauging a certain line of machine work. The logical outcome of that curve would have been to discover the reason for the distribution, and scotch it as far as possible. The attempt would, in all probability, have been (and may have been for all I know) successful in more ways than one. But had it been known precisely why any given article was 0·002 in. out, the statistical data would be destroyed prenatally.

So, we return to the statistic of accidents. If the result of analysis show no tendencies, it teaches us nothing, and so far *is* valueless; if it show some tendencies then we may begin to inquire, what is the cause, to discriminate and look for the remedies. Possibly, as you properly suggest in other words, it may be found that all the significant variables are known in a large number of the events, in which case a small statistic may be emasculated and the first deduction wrong. Publication is not necessarily premature although it may be dressed in such a form as to be dangerous. Otherwise, that is the very purpose of the analysis, be the statistic small or large; although in the latter case it is generally found that the result still holds true. Insurance rates are based on such so far as practicable.

Yours faithfully,
Alexander Jude.

Belliss and Morcom, Limited, Ledsam-street Works, Birmingham. December 8, 1924.

"THE WHITWORTH SCHOLARSHIPS."

To the Editor of Engineering.

Sir,—In reference to Mr. A. D. Ottewell's letter in last week's issue of Engineering, and also to your leading article, I would suggest that Mr. Ottewell has rather missed the point. His letter gives one the impression that only dockyard apprentices are eligible to compete in the examinations for Whitworth awards. This, of course, is not so. Criticism, if any, should be entirely from the point of view of percentage of awards, and not of percentage amount or value of the awards. If apprentices from some of the private manufacturing and industrial concerns can win 21 per cent. of the awards, then, with a slightly higher standard attained by themselves, they should be capable of obtaining more.

Whilst admitting that, owing to the excellent system of training of apprentices in the dockyard establishments, the apprentices therefrom do have an advantage, it does not follow that they should be barred from competing, and it would be decidedly unfair to make special stipulations and regulations for Dockyard apprentices to compete under, against other competitors.

There are exceptions, but generally the Dockyard apprentice, after finishing his four years' course at the Dockyard school (entailing the most severe competition and hard study, apart from his practical work), has to take a year's evening course at the local technical college to prepare him for the Whitworth Scholarship examination. I suggest that, although it would be an excellent idea (as advocated in your reply, sir, to Mr. Ottewell's letter) for the employers to take a hand in the training of their youths—yet I suggest that it is up to the youths themselves (and evening classes at technical schools and colleges are quite within their reach) to work hard, as the dockyard apprentice has to do, to ensure attaining the necessary theoretical standard to enable them to compete on an equal footing with the Admiralty-trained apprentice.

I would conclude, sir, by submitting to you that it is in this theoretical knowledge, rather than the practical, that they are lacking, and, further, that if the value of the awards (and the awards themselves) were as well known amongst apprentices generally as they are amongst Dockyard apprentices, then the competition from the former might be more vigorous in years to come.

Yours faithfully,
J. Hector Macdonald,

Whitworth Scholar, 1919, Portsmouth Dockyard.
10, Luton Road, Bournbrook, Birmingham.
December 3, 1924.

To the Editor of Engineering.

Sir,—Your correspondents seem to be under great misapprehensions with regard to the training of apprentices in H.M. Dockyards. I speak as an ex-apprentice, and more particularly for Portsmouth Yard, although I believe that conditions in other yards are the same.

It is quite true that the apprentices are weeded out. It is obvious, if the curriculum be studied, that only those fortunate enough to have mental endowments rather above the average are able to take advantage of such an advanced and intensive course of study as that provided in Royal Establishments. The unfit are not permitted to retard the general progress and the pace is that of the fastest.

The syllabus is vocational and is very much removed from that of the Whitworth and Royal Scholarship examinations—it was even more so under the old regulations, when the record of success for the Dockyards was as great as at present. This school syllabus is very rigidly adhered to, and apart from the acquirement of a sound technical education, the only immediate object at all studied is the gaining of Admiralty Cadetships in Naval Construction, in which competition there is great inter-port rivalry. Candidates from the Dockyards for Whitworth Scholarships have always been obliged to study for the examination privately from books. The new Whitworth syllabus, if it has done anything, has lowered the standard and, consequently, made it more difficult for the highly-trained Dockyard apprentice to achieve a success, since his field of competitors is vastly widened.

It is puzzling to think of any source of obtaining back papers for examinations not equally open to any one else. To my knowledge, no Dockyard candidate has obtained any such papers unless it be from ex-candidates—certainly he has not obtained them through his school.

The period of coaching at the expense of practical work is *not* very large. Of the 47 working hours per week, the apprentice spends 6 hours at school—in addition, 6 hours of his own time are devoted to evening attendances. For ten weeks of the year the schools are completely closed.

In conclusion, the importance and class of the work undertaken by H.M. Dockyards is sufficient proof that their mechanics, in spite of education, are as competent in that capacity as their outside contemporaries.

I am, Sir, Yours faithfully,
Albert H. Couzens.

Union Society, University College, London, Gower-Street, W.C. December 8, 1924.

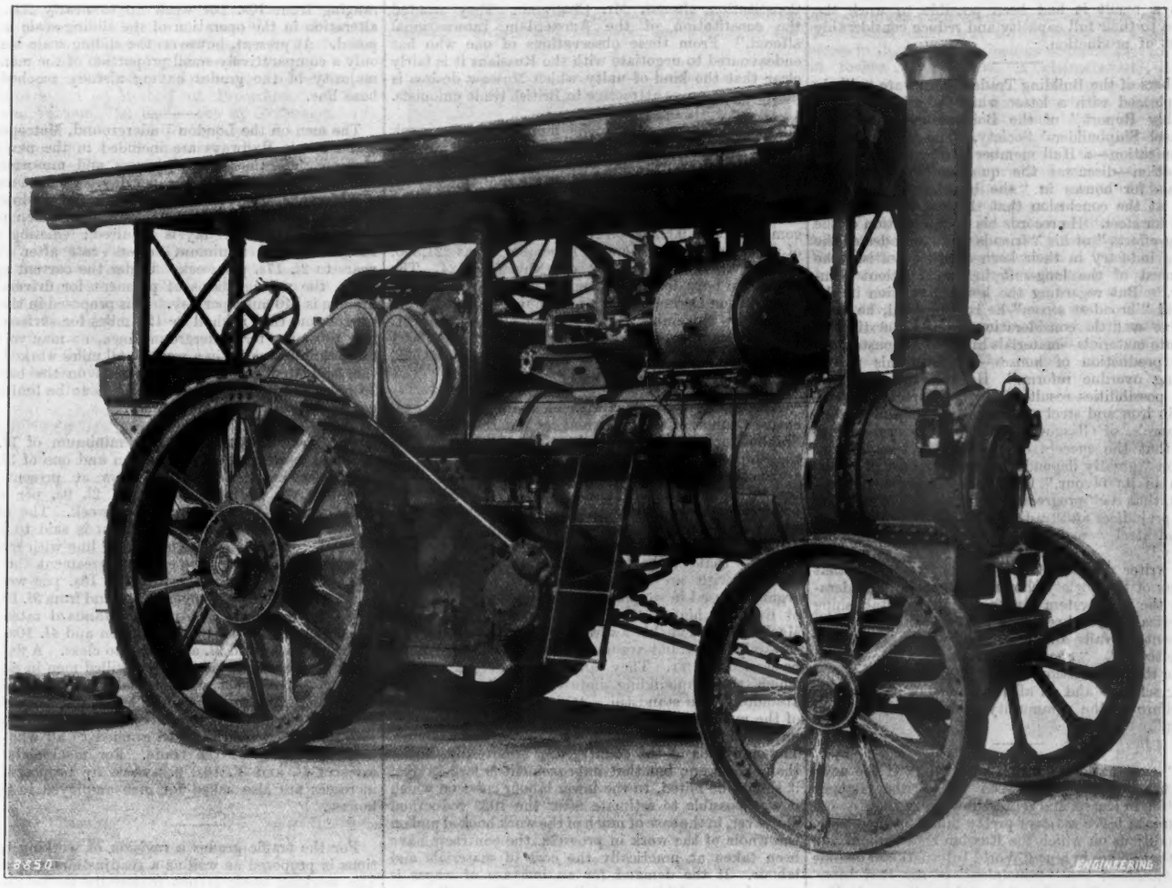
TWO-CYLINDER COMPOUND STEAM TRACTION ENGINE.

A new model of steam traction engine which Messrs. Marshall, Sons and Co., Limited, of Gainsborough, have recently introduced, is shown in the figure opposite. Messrs. Marshalls' have, of course, built traction engines for very many years, and their products in this, as in many allied directions, are known over a large part of the world. Even in such an established article as a Marshall traction engine, however, useful modification is possible, following the improvements in material and the general engineering advance which recent years have shown, and the engine we illustrate represents an entirely remodelled and modern design. Every component throughout the machine, including the boiler, is built strictly to gauge, and templates and interchangeability is guaranteed by the makers. New parts from stock will drop into place without bedding or fitting. This is a convenience under any circumstances, but is likely to be particularly appreciated in the case of road-side repairs following accidental breakdowns, while its value in some of the more remote parts of the world to which traction engines penetrate requires no emphasis.

The machine, which is built of various capacities, is fitted with a compound two-cylinder engine, the two cylinders which are made in a single casting being steam jacketted. The steam is distributed by balanced piston valves of cast-iron, with cast-iron rings. Working liners are fitted both to the cylinders and valve chests. The starting valve is placed on the top of the cylinders to ensure dry steam, while a by-pass valve is provided, so that high-pressure steam can be admitted to the low-pressure cylinder for starting purposes, and for temporary increase of power when the machine is ascending steep inclines or crossing difficult ground. The piston-rod stuffing-boxes are fitted with metallic packings of the labyrinth type, which remain steam tight without any soft packing. The crossheads are of malleable cast-iron with adjustable slide blocks, and the guides are of cylindrical design. The connecting-rods are of wrought-iron, turned and polished, and are fitted with adjustable gun-metal bearings at each end. The crankshaft is made from a single ingot; it runs in self-oiling bearings. A governor of the Pickering type is driven by belt from a pulley on the

TWO-CYLINDER COMPOUND STEAM TRACTION ENGINE.

CONSTRUCTED BY MESSRS. MARSHALL, SONS, AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.



crankshaft, and operates direct on the equilibrium throttle valve. The crankshaft carries a wide fly-wheel which may be used to drive external machinery by belt. The link reverse motion is of the "radial" type, in which only one eccentric sheave, one strap and one rod per cylinder are necessary.

The boiler is of the locomotive multi-tubular type, with one longitudinal seam in the barrel, and with a fire-box of Messrs. Marshalls' well-known cambered crown type. The boiler front plate is reinforced by a steel T-section stiffener, and the smoke-box tube plate is strengthened by a transverse corrugation. The usual boiler mountings are fitted. A steel tender is bolted to the extended horn plates of the boiler fire-box. The lower part of this tender, below the footplate, forms a water tank and the upper part a coal bunker. A geared-down feed pump is fitted; this runs at half the speed of the engine, and a water lifter with 26 ft. of wire-armoured suction hose is fitted to the back of the tender.

The transmission gearing is arranged to give road speeds of 2 and 4 miles an hour, the gear wheels being of cast-steel. The differential is arranged on the four-pinion system, with locking pins, and enables the engine to travel round sharp curves, preventing also undue wear on the wheels and damage to the roads. The rear axle is of large diameter and has four machine-cut key-ways, two for securing the winding drum centre and two for the bevel wheel of the differential gear. The axle can be withdrawn without removing the tender. The winding drum carries 50 yards of steel wire rope, and a swivelling guide pulley is fitted to enable the rope to be worked over a wide radius without shifting the position of the engine. The hind wheels are made from T-steel hoops, specially rolled for the purpose, with mild-steel spokes and cast-steel bosses. A screw brake is fitted, acting direct on the back axle. The brake strap is lined with Ferodo. The front wheels are of similar construction to the rear wheels, but have cast-iron bosses and steel over-tyres. The steering gear is of the worm and chain type, as can be seen from the figure, the front axle being carried on a steel fore-carriage. The machine can, if required, be fitted with a feed-water heater, injector and additional water tank, also with a fuel rack around the top of the tender when wood is to be carried as fuel.

THE BRITISH ACETYLENE AND WELDING ASSOCIATION.—At a meeting of the British Acetylene and Welding Association in the Old Colony Club, Aldwych, London, on Thursday, December 4, when Mr. C. J. Quirk presided, a lecture was delivered by Mr. H. J. Gough, of the National Physical Laboratory. After describing the nature of alternating stresses, reviewing early experimental work and discussing the effects of their action, the lecturer showed how fatigue phenomena varied with the range of the loads, their mean value and the periodicity of the alternations. He then showed what deductions could be made from fatigue tests, which were of service in engineering design, but emphasised the necessity for knowledge of the shock-resisting properties of the material, such as could be determined by the Izod test, in addition to the information available from the fatigue tests.

THE LATE MR. ROBERT POLLOK.—The funeral took place on the 22nd ult. at Barrow-in-Furness of Mr. Robert Pollok, a noted engineer associated with the shipbuilding industry on the Clyde, and elsewhere, for many years. After completing his education at Glasgow High School, Mr. Pollok served his apprenticeship with Messrs. Hannah, Donald, and Wilson, Limited, of Paisley. At the age of 21 he became chief draughtsman to Messrs. A. McMillan and Son, of Dumbarton, subsequently attaining the position of assistant manager with this firm. Later he was appointed manager of the Clydebank Shipyard of Messrs. John Brown and Co., Limited, which position he held for ten years. During this period the important work undertaken by the company included the construction of the Lusitania for the Cunard Line. In 1911, Mr. Pollok joined the staff of Messrs. Vickers, Limited, at Barrow-in-Furness. During the following year he became shipyard manager, which post he held until he retired in 1921. During the war years he specialised in submarine construction. Mr. Pollok, who was 65 years of age, was a member of the Institution of Naval Architects and of the Institution of Engineers and Shipbuilders in Scotland.

LABOUR NOTES.

AT the Hull Trades Union Congress, it will be recalled, a resolution was passed calling on the General Council to deal with the situation created by the multiplicity of trades unions and the conflicting methods of organisations which are being followed. According to "The Labour Press Service," the resolution was interpreted by some trade unionists as a mandate for the framing of a scheme of organisation by industry, and by others as a confused and self-contradictory declaration in favour of two incompatible methods of industrial organisation. Its terms were certainly contradictory. The General Council, however, interprets it, the Labour movement is now semi-officially informed, "as a mandate for the production of a scheme for promoting, wherever possible, the amalgamation of unions in the same industry or service, and where this proves impossible, for any good reason, for the federation of existing unions on a firm and workable basis." The General Council hopes, it seems, to be able to frame a policy which "will promote amalgamation and the united front, without doing violence to the craft or occupational principle on the one hand, or the large-scale organisation by industry on the other hand." The problem is stated to be not so difficult as it appears to be at a first glance. The truth is, however, as every experienced trade unionist knows, exactly the opposite. The problem looks much easier to solve than will be found to be the case when the General Council settles down to its task.

An official report submitted to the Russian Textile Workers' Congress stated that the Textile Workers' Union now has a membership of 515,000, an increase of 26·9 per cent. since 1922. About 97 per cent. of the workers in the textile trade are organised, and of the total number of members 68 per cent. are employed in the cotton industry, 14 per cent. in the wool industry, and 18 per cent. in the flax industry. In round figures 27,000 textile

workers are unemployed. Wages, which on the average were 6 roubles 43 kopecks (pre-war roubles) in 1922, had risen to 19 roubles 11 kopecks in July, 1924. The union, it was added, had co-operated with the administrative authorities of the textile industry in carrying out the concentration of the industry, and as a result it had been possible to work the factories to their full capacity and reduce considerably the cost of production.

Members of the Building Trades Unions are unlikely to be pleased with a letter which is printed in the "Monthly Report" of the Boilermakers' and Iron and Steel Shipbuilders' Society. The writer of the communication—a Hull member of the boilermakers' organisation—discusses the question of alternative materials for houses in "the broadest sense," and arrives at the conclusion that there is something to be said for steel. He records his "appreciation of the untiring efforts" of his "friends and comrades of the building industry in their keen desire to satisfy the great need of the long-suffering and patient community." But regarding the housing position in the aforesaid "broadest sense," he is compelled, he says, "to give a little consideration to the question of substitute materials—materials hitherto not customary in the production of houses—to meet this urgent and long overdue reform." He believes there are "great possibilities resultant upon the recent experiments in iron and steel at Messrs. Weir's and Messrs. Beardmore's, of Glasgow." While he is prepared to admit that the success of the new system of construction "greatly depends upon the weight of public opinion in its favour," he "reluctantly recognises," he says, that its "progress may be somewhat retarded by old prejudices and traditions, as was the case when iron and steel were introduced into the shipbuilding industry."

The writer of the letter goes on to suggest that members of the Society should give careful consideration to the new system "with a view to establishing its practicability and relieving the acute distress which at present prevails amongst many thousands of our fellow-citizens." "Secondly," he says, "we should press for the introduction of this system in all municipal housing schemes and on all public bodies catering for the welfare of the community under the heading of housing."

The "explanations" which have followed the news about the agreement between the British Labour Delegation in Russia and representatives of the Russian trade unions leave matters pretty much as they were. The conditions on which the Russian trade unions will merge themselves in a new World International include the adoption of the "principles" of the Red International Labour Union by all the other adhering bodies, and that, as most representative British workers are aware, is exactly what these other organisations are strongly disinclined to do. In the speech which he delivered in the Congress M. Tomski made that perfectly clear. He said:—"Our trade unions in the U.S.S.R. are a basic part of the Red International of Labour Unions. It must be understood that our trade unions consider as binding on themselves all the decisions of the Red International of Labour Unions, which decisions are ours. . . . That is why we, who have undertaken these measures for closer contact between the trade unions of the U.S.S.R. and those of Great Britain cannot—and it must be distinctly understood that we cannot—forget for one moment our solidarity with those trade union organisations of Germany, France, Czecho-Slovakia, Italy, the Balkans, Poland, and other countries which are struggling in complete agreement with our ideas."

The trade union organisations mentioned by M. Tomski—those of Germany, France, Czecho-Slovakia, Italy, the Balkans, &c.—are Communist bodies whose avowed aim is, like that of the corresponding group here, to destroy the existing unions. At more than one of the sectional Internationals—notably that of the Metal-workers—that has frequently been stated, occasionally with considerable bitterness. The effect therefore, of such a joint Russo-British effort to consolidate the forces of the world's organised labour may, therefore, easily be, British trade unionists should note, to split the movement from top to bottom.

In his speech at the recent Detroit Convention of the International Association of Machinists, Mr. J. T. Brownlie, the president of the Amalgamated Engineering Union, explained his own and his organisation's attitude towards the Russians. "I stand," he said, "for the admission of the Pan-Russian Metal Workers into the International Metalworkers' Federation, and I have always done so, but only on the specific understanding that they accept the constitution of the International Metalworkers' Federation, obey its rules, and work in unison with the other national organisations affiliated thereto. . . . As I told our Russian friends whom I met in Vienna on July 27 and 28, giving these specific undertakings does not debar them from exercising their legitimate right to influence the decisions and policies of the Federation in accordance with the recognised procedure of democratic assembly. The question was left in abeyance. They wanted our Constitution altered, Mr. Chairman. They wanted the constitution of the Amsterdam International altered." From these observations of one who has endeavoured to negotiate with the Russians it is fairly clear that the kind of unity which Moscow desires is not likely to prove attractive to British trade unionists.

The official unemployment figures for the week ending December 1 show an increase in the number of idle men and women, and a decrease in the number of idle boys and girls. According to the Ministry of Labour, 910,100 men were on the registers of Employment Exchanges in Great Britain on December 1, as compared with 909,960 on November 24. The number of women on the registers on December 1 was 221,800, as compared with 220,832 on November 24. The number of boys decreased from 31,397 on November 24 to 31,000 on December 1, and the number of girls from 28,403 on November 24 to 27,300 on December 1. The total number of unemployed persons on December 1 was 1,190,200; on November 24 it was 1,190,592, and on December 31, 1923, 1,285,623.

Acting on the instructions of branches, the executive Council of the Boilermakers and Iron and Steel Shipbuilders Society have asked for a conference with the Shipbuilding Employers Federation to discuss an application for a wages advance of 10*s.* per week. An Industrial Court award issued in June restored to the boilermakers, in common with the other shipyard trades, 7*s.* per week of the 10*s.* per week taken off early in 1923. The claim of the ironworkers' organisation is that the balance of the 10*s.* should now be restored with an addition of 7*s.* per week. An argument used in support of the claim is that the cost of living is higher than it was when Sir William Mackenzie issued his award. The cost of living is certainly higher, but arguments founded on it can easily be carried too far. They can be carried to a point at which the shipbuilding industry would be brought absolutely to a standstill. It is also urged on behalf of the men that the state of the trade has sufficiently improved to warrant the increase of wages demanded. The shipyards of the country are, admittedly, busier than they were, but that improvement is largely due, it should be noted, to the lower labour costs on which it was possible to estimate after the 1923 reduction. Moreover, in the case of much of the work booked and on the whole of the work in progress, the contracts have been taken at practically the cost of materials and labour. If the demand for an increase of wages is pressed a two-fold very undesirable effect will be to involve many shipbuilding firms in heavy losses, and at the same time enormously increase unemployment. Regarded as tactics, the move seems to be singularly unhappy. Few demands for higher wages can ever be put forward by an organisation with unemployment as high as that indicated by the present figure for the Boilermakers' Society.

A writer in a Labour publication asks when the Government intends to ratify the Washington Convention on the 48 hours' week. Other countries are, it is stated, waiting for Britain to act in the matter. People who are intimate with industrial conditions abroad are not, however, quite so optimistic about the attitude of these "other countries" as this authority seems to be. There is, as a matter of fact, no reason to believe that the moment after this country ratifies the Convention all its rivals in other parts of the world will follow the example. On the contrary, it is becoming clearer every day that most of them intend to retain for as long a time as possible their present working weeks. In these circumstances, the proper course to follow in the interest of British industry and British labour is only to ratify on the understanding that every other party to the bargain does so unconditionally at the same time, and that the Convention comes into force on the same day in every contracting country. It would be foolish to ratify as an example to others.

On December 10 the terms of the National Union of Railwaymen's new programme were officially communicated to the railway managers. In respect of the salaried staff, the N.U.R. and the Railway Clerks' Association jointly propose that the minimum for all classes shall be increased by 10*l.* a year, and the period in which a man may reach the maximum in his particular class be reduced from four years to one year. The solution suggested of the "stagnation" difficulty is that a man who has been in his particular class for two years shall receive the minimum of the class next above, and after serving a further two years the maximum of that class. Alterations are also proposed in the payment for night duty and increases are desired for women and girl clerks.

For the traffic or conciliation grades, including employees at docks, but excluding shopmen and men employed in power houses and stores departments, increases—most of them on basic rates—are asked, ranging from 10*s.* per week up to nearly 20*s.* No alteration in the operation of the sliding scale is proposed. At present, however, the sliding scale benefits only a comparatively small proportion of the men, the majority of the grades having already reached the base line.

The men on the London Underground, Metropolitan and Electric Railways are included in the new programme. For locomotive drivers and motormen, a flat rate is demanded of 16*s.* per day. Current weekly wages range from 4*l.* 10*s.* after six years down to 3*l.* 12*s.* For firemen and assistant motormen a flat rate of 12*s.* 6*d.* per day is required; existing rates range from the minimum drivers' rate after eleven years to 2*l.* 17*s.* per week. Under the current agreement, the mileage basis of payment for drivers and firemen is 140 miles per day. It is proposed in the new programme that it shall be 120 miles for surface men and 100 miles for underground men, no man to work more than 840 miles in a week. All miles worked over the stipulated figure are to be paid on the basis of 15 miles per hour, but the mileage is to be limited as nearly as possible to 120 per day.

In respect of porters a new minimum of 3*l.* 3*s.* per week is demanded for London and one of 3*l.* per week elsewhere. Grade I porters at present get, including the sliding scale bonus, 2*l.* 9*s.* per week, and Grade II porters 2*l.* 7*s.* per week. The object of the proposals affecting signalmen is said to be to bring the original scheme more into line with modern requirements. Under the current agreement the base rates for signalmen range from 3*l.* 15*s.* per week to 2*l.* 8*s.* per week for passenger boxes, and from 3*l.* 12*s.* 6*d.* to 2*l.* 8*s.* for goods boxes. The standard rates proposed range from 4*l.* 18*s.* in London and 4*l.* 10*s.* elsewhere to 3*l.* 3*s.* and 3*l.* according to class. A flat rate of 4*l.* per week is demanded for skilled men in railway shops; 3*l.* 10*s.* per week is asked for semi-skilled men, and 3*l.* per week for unskilled men. The grading of skilled mechanics is to be abolished, and the new flat rate for skilled men is to be applied to all who have been five years at the trade. For machinists base rates of 4*l.* and 3*l.* 16*s.* per week are proposed, and increases are also asked for men employed in power houses.

For the traffic grades a revision of working conditions is proposed as well as a readjustment of wages. The working week is not materially to be altered, except in certain grades—such as goods and cartage men, permanent way men and signal and telegraph department staff—where a working week of 44 hours is proposed. The present working week is one of 48 hours. A six hours' day is asked for signalmen in boxes where the work is very heavy. Night duty payment is to operate from 6 p.m. to 6 a.m., instead of 10 p.m., to 4 a.m., and the rate is to be time and a-half, instead of time and a-quarter. The new overtime rates demanded are time and a-half, between 6 a.m. and 6 p.m., and double time between 6 p.m. and 6 a.m. Other important proposals include a 12 days' instead of a six days' annual holiday, the inclusion of meal times in the eight hours of duty, pensions at 60 years of age for all grades, and the application of the guaranteed day and week to all grades who do not at present enjoy it.

The Ferrantians.—The date for the next re-union of old Ferrantians has now been fixed for Wednesday, December 17, at the Hotel Cecil, London. Dr. S. Z. de Ferranti will be the guest of the evening, and the Chair will be taken by Mr. H. W. Kolle. It was originally announced that Mr. C. H. Wordingham, C.B.E., would preside, but owing to illness, this will not be possible. There has been a considerable response from Ferrantians in all parts of the country, but the Hon. Secretary, Mr. W. E. Warrilow, 40, Mildred-avenue, Watford, would still like to hear from further Ferranti men whose attendance would be welcomed.

The Institution of Automobile Engineers.—The annual dinner of the above institution, which as usual was very successful, was held at the Connaught Rooms, London, W.C. 2., on the 19th ult. In distinction from the practice of many of the technical institutions, the Institution of Automobile Engineers admits ladies to its annual dinner. This procedure makes the event a very definite social function. In the present case the ladies' element extended even to the speeches, an excellent and amusing reply to the toast of "The Guests" being made by Lady Parsons. The speaking throughout was above the level to which one is accustomed, and particularly would we mention the contributions of Dr. Ormandy, the President, and Mr. W. J. Tennant.

THE ELASTIC LIMIT IN TENSION, AND ITS INFLUENCE ON THE BREAKDOWN BY FATIGUE.*

By J. M. LESSELLS, B.Sc.

(*a*) *Introduction.*—The degree of influence which the elastic properties of materials exert on their actual breakdown by fatigue does not appear to receive the attention which the subject warrants.

The paper is divided into five sections as follows :—(*b*) Apparatus. (*c*) Method of Procedure. (*d*) Tension and Fatigue. (*e*) Endurance by Deflection. (*f*) Conclusions.

(*b*) *Apparatus.*—The apparatus used is described as follows :—(1) *Tensile Testing Machine.*—This machine is 100,000 lb. capacity, and represents the standard equipment of T. Olsen and Co., Philadelphia. It is part of the equipment in the research laboratory of the Westinghouse Company, and is of a beam type.

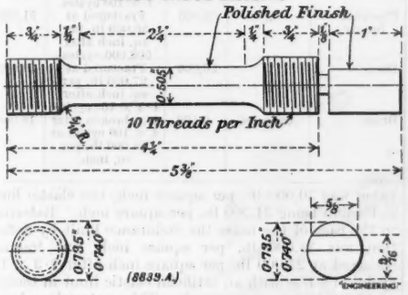
(2) *Tensile Test-Piece.*—The test-piece used is shown in Fig. 1. It was designed by the author, and differs from the American standard test-piece in that the radius at the neck was made larger in order to eliminate excessive stress concentration.

(3) *Fatigue Testing Machine.*—This was originally made by T. Olsen and Co., Philadelphia, re-designed with provision for heavier ball-bearings and the application of a lubrication system. Fig. 2 shows the machine as modified. In this type of machine the main spindle is driven by gearing from an electric motor. This spindle is hollow and a test-piece can be fixed in each end of the spindle by means of tapered sleeves. The load is applied to the test-piece through ball-bearings, which fit on the end of the test-piece. It will be appreciated that when the test-piece was fitted into this machine and loaded and the machine set in motion, the material of the test-piece was subjected to reversals of stress. The speed is 1,300 r.p.m.

(4) *Fatigue Test-Pieces.*—The test-piece used is shown in Fig. 3. The taper of test-piece is such that the maximum stress is nearly uniform over 1 in. of length.

(5) *Deflection Apparatus.*—The apparatus shown in Figs. 4 and 5, was designed by the author, being modelled on the original apparatus built and used at the National Physical Laboratory, Teddington. It consists essentially of a stand carrying a vertical scale graduated in inches, a telescope, and a lamp in the form of a point source of light. A rack and pinion was embodied in order that this lamp could be moved vertically over the scale provided. By this arrangement the lamp filament could be moved over the scale so that its reflection in the mirror attached to the test-piece could be seen in the telescope for different angles of inclination of the mirror.

Fig.1. TENSILE TEST SPECIMEN. 2-INCH GAUGE LENGTH.



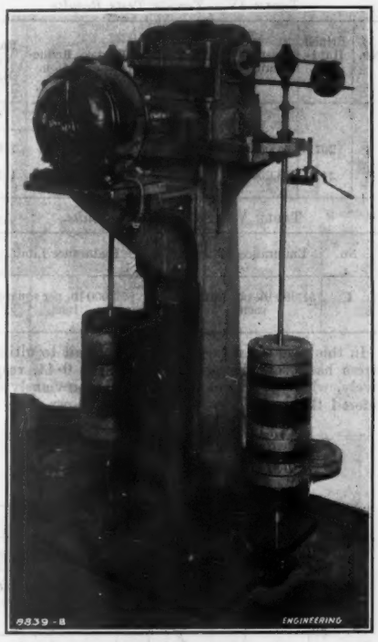
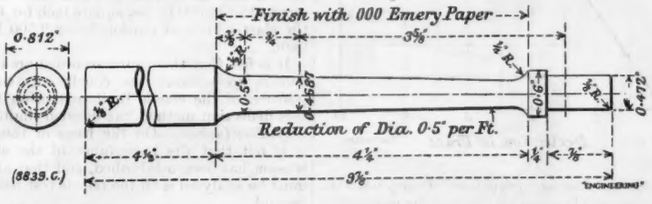


FIG. 2.

Fig.3. CANTILEVER TEST SPECIMEN.



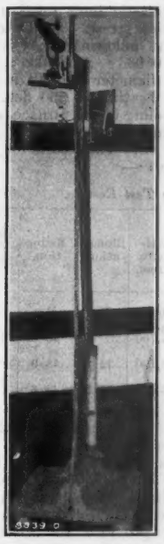


FIG. 4.

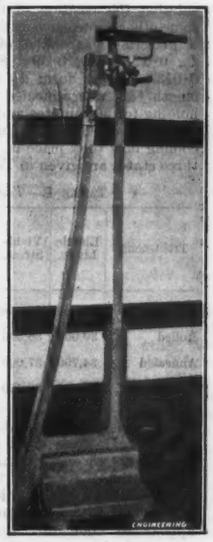


FIG. 5.

Fig.7. TENSILE TEST.

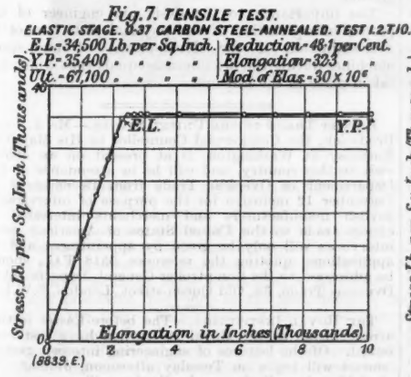
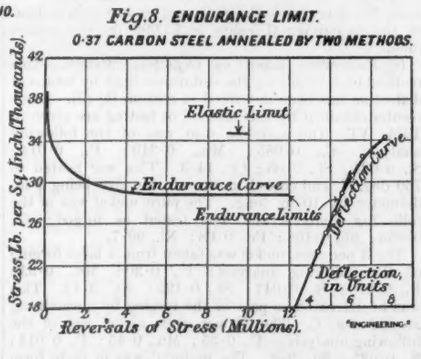


Fig.8. ENDURANCE LIMIT.



(*c*) *Method of Procedure.*—(1) *Tensile Tests.*—In conducting the tensile tests, the testing machine and test-piece described were used. The test-piece was mounted in the machine and a small load of 20 lb. applied. An Ewing extensometer set for 2 in. gauge length was then attached to the test-piece. The machine was then set in motion so that the head was moving at the rate of 0·04-in. per minute. The load and extension were recorded for successive extensions of 0·002-in. until a total of 0·01-in. extension was reached. The extensometer was then removed and the speed of the machine increased to 0·58 in. per minute until fracture occurred. The total elongation and reduction of area were next measured and recorded, from which percentages were calculated. The elastic stage was then plotted to scale, using stress in lb. per square inch as ordinate and extension in inches as abscissæ. A characteristic diagram obtained in shown in Fig. 7. The proportional limit described herein as the elastic limit was taken as that stress on this diagram at which extension ceased to be proportional to applied load. The yield-stress was taken as that stress corresponding to an extension of 0·01 in. It will be observed that the ratio of yield-stress to elastic limit defined the shape of the initial stage of the tensile test diagram.

(2) *Fatigue Tests.*—In conducting the fatigue tests a minimum of six test-pieces was necessary for each test. The first test-piece was assembled in the machine and the load was calculated corresponding to a stress of 75 per cent. of the ultimate stress in tension, which value was obtained from the tensile tests. The machine was then set in motion and weights added to the end of the test-piece by increments of 5 lb. until the requisite load was obtained. The reading of the revolution counter at which this load was reached was then taken. After fracture was obtained the reading of the counter was again taken and the total cycles of stress, obtained from the difference of these counter readings, recorded. The second test-piece was then assembled as before, but the load was reduced from the value used in the previous case. The total cycles of stress to fracture were again recorded. This was again repeated on the remaining test-pieces, the load being gradually reduced on successive pieces until it was found that fracture could not be obtained although running from 20×10^6 repetitions. Since the machine was designed to run at 1,300 r.p.m., this last test had to be run continuously for 11 days. The cycles of stress and corresponding stress values were plotted as shown in Fig. 8. The curve obtained was hyperbolic in form, and seemed to be asymptotic to a horizontal line drawn parallel to the horizontal base line. Accepting the hypothesis advanced by many previous investigators, it was assumed that if the material safely withstood 20×10^6 cycles of stress without failure, it would withstand an infinite number of such cycles. This stress value was therefore taken as the endurance limit.

(3) *Deflection Fatigue Tests.*—The apparatus described in (*b*) (5) was used in conjunction with the fatigue-testing machine and test-piece. A test-piece was mounted in the machine and the mirror screwed in the end. This mirror was then adjusted by the screws provided, so that the plane of the mirror was at right angles to the axis of the test-piece. The machine was then set in motion, and the lamp so adjusted on the scale that the image could be observed in the telescope. The reading on the scale was then recorded. A load of 5 lb. was then applied to the test-piece, and the lamp moved down until the filament was again visible in the telescope. This was then repeated for

* Paper, abridged, read before the Institution of Mechanical Engineers on Friday, December 5, 1924.

consecutive 5 lb. increments until the load was such that the endurance limit had been exceeded, as evidenced by the high temperature attained by the test-piece. These readings of load were then expressed as stress and plotted with the corresponding deflections. A typical curve is shown in Fig. 9. It will be noted that a point on the curve is reached at which deflection ceases to be proportional to load. This point has been called the endurance limit of the material by certain investigators at the National Physical Laboratory. These deflection tests can be made in approximately 30 minutes; it will, therefore, be appreciated that such a test would be truly valuable if always reliable. The present work imposes decided limitations on its use however.

(*d*) *Tension and Fatigue.*—Attempts have been made to show that the endurance limit or true elastic limit is related to the ultimate stress in tension alone. By concentration on one steel, certain results are given here to show that the endurance limit value, while being related to the ultimate stress in tension, is largely influenced by the two factors: (1) Internal stress as measured by the relative position of yield stress and elastic limit and (2) microstructure. Carbon content may have a bearing also on the final value, but from the data discussed it will be seen that this may be small.

(1) *Internal Stress.*—The state of internal stress in a material can probably best be indicated by considering the position of the elastic limit relative to some other value, such as the yield stress. To illustrate a material was taken of the following analysis:—C., 0·37; Mn., 0·59; Si., 0·036; S., 0·035; P., 0·013. In bar form 2¼ in. diameter and 42 in. in length this was annealed by heating to 850 deg. C. holding for 30 minutes and cooling in the furnace, and was normalised by heating in a similar manner but cooling now took place in the air. The results for the three states are given in Table I:—

TABLE I.—*Tensile Test Results.*

Treatment.	Elastic Limit.	Yield-Stress.	Ultimate Stress.	Elongation.	Reduction.	Ratio Y.P. / E.L.
	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Per cent.	Per cent.	
Rolled ..	30,000	36,300	75,700	31·4	49·0	1·20
Annealed ..	34,700	37,000	68,700	32·3	48·0	1·07
Normalised ..	34,725	39,450	76,800	31·0	48·6	1·13

For the annealed state of the material in which the internal stress must be a minimum, the ratio of yield-stress to elastic limit is also a minimum. This means that the smaller the internal stress becomes, the more does the elastic limit approach the yield-stress, and in a well-annealed material these values appear to coincide. Again, provided the ultimate stress remains constant, the lower the ratio of yield-stress to elastic limit, the higher will the endurance limit become. A low elastic limit value means a low endurance limit value. Table II gives the values of the endurance limits for the three states. It will be

TABLE II.—*Fatigue Test Result.*

State.	Endurance Limit.	
	By experiment.	As calculated.
Rolled	28,000	28,000
Annealed	28,600	28,500
Normalised	29,300	30,000

noted that the endurance value for the annealed material is higher than that for the rolled material, although the ultimate stress in tension has been reduced from 75,700 lb. per square inch to 68,700 lb. per square inch by annealing. On the other hand, the endurance limit for the normalised state has been increased to 29,300 lb. per square inch. These changes appear to be explained by the reduction in the ratio of yield-stress to elastic limit due to a reduction in the internal stress existing in the material. In order to apply these results in practice the following theory has been developed. If x_1, F_1, f_1 and k_1 represent respectively the ratio of yield-stress to elastic limit, ultimate stress in tension, the endurance limit and the ratio f_1/F_1 for one particular state and x_2, F_2, f_2 and k_2 similar values for a second state, then:—

$$f_2 = F_2 \times k_1 \times \frac{x_1}{x_2} \quad . \quad . \quad . \quad (1)$$

Hence, if the endurance limit and tensile test data for one state be known, the endurance limits for other states can be calculated from the tensile test values for these states.

Applying equation (1) for the three states of the material the results obtained are shown in the right hand of Table II. All previous remarks refer only to materials of a similar structure.

(2) *Microstructure.*—The effect of microstructure can at once be shown by referring to the experimental values, Tables IV and V, obtained from the same steel oil-quenched in water from 850 deg. C. and tempered to give the recorded Brinell hardness.

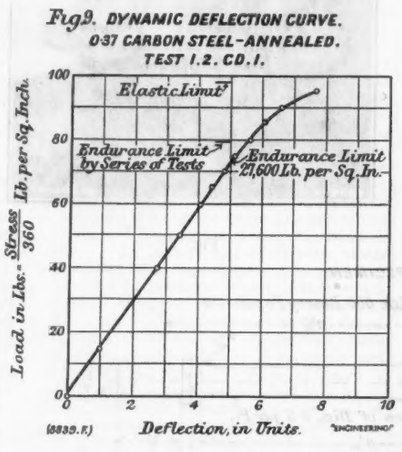
TABLE IV.—*Tensile Tests Results.*

No.	Brinell Hardness No.	Elastic Limit.	Yield-Stress.	Ultimate Stress.	Elongation.	Reduction.	Ratio Y.P. / E.L.
		Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Per cent.	Per cent.	
4	207	64,000	69,460	105,460	21·8	56·1	1·08
6	248	68,000	80,000	116,800	16·4	40·9	1·185

TABLE V.—*Fatigue Test Results.*

No.	Endurance Limit.	No.	Endurance Limit.
4	51,000 lb. per square inch.	6	52,000 lb. per square inch.

In this case the ratio of endurance limit to ultimate stress has been increased to 0·48 and 0·44, respectively, whereas for the annealed state previously considered this ratio was 0·415, which shows that this



ratio depends on the microstructure of the material. Applying equation (1) again and basing the calculation on results for state No. 4 the endurance limit for state No. 6 becomes 51,400 lb. per square inch, instead of the experimental value of 52,000 lb. per square inch.

(*e*) *Endurance Limit by Deflection Method.*—This method of determining the endurance limit by means of deflection has been described in section (*b*) (5). Some results obtained by this method of testing are given in Table VI. The stainless iron was of the following analysis:—C., 0·085; Mn., 0·310; P., 0·014; S., 0·024; Si., 0·05; Cr., 14·3. This was heated to 760 deg. C. and cooled in the air, the size being ¾ in. diameter by 10 in. long. The pure nickel was of the following analysis and was tested as forged:—C., 0·065; Si., 0·108; Fe., 0·08; Ni., 99·7.

The 3 per cent. nickel was taken from a large forging of the following analysis:—C., 0·30; Mn., 0·53; P., 0·018; S., 0·047; Si., 0·195; Ni., 3·12. This was heat-treated as part of the forging by normalising at 800 deg. C. The 3½ per cent. nickel was of the following analysis:—C., 0·35; Mn., 0·45; P., 0·013; S., 0·025; Ni., 3·4. The material was in plate form 70 in. diameter by 2½ in. thick, and was normalised at 840 deg. C. and tempered at 730 deg. C.

Referring to Table VI, it will be seen that it can be divided into two parts by a horizontal line drawn below the seventh test. All materials above the line have elastic limits in tension higher than the endurance limit as found by deflection method, and this deflection result is observed to be in good agreement with the endurance limit as found by the long tests recorded in column 4. On the other hand all materials below this horizontal line have their elastic limits below the value of the deflection endurance limit, and this latter is observed not to be in good agreement with the results of the long-time tests. The case of the non-ferrous material is no exception to this statement, because these materials being cold worked have an artificially raised elastic limit. The extent to which this deflection endurance limit can be misleading is seen from the case of the 3 per cent. nickel steel. In this case the deflection method indicates an endurance limit of 46,800 lb. per square inch, whereas the true endurance

TABLE VI.—*Fatigue Test Results.*

Material.	State.	Elastic Limit.	Endurance Limit.	
			Long Method.	Short Method.
		Lb. per sq. in.	Lb. per sq. inch.	Lb. per sq. in.
0·37 carbon	Rolled	30,000	28,000	30,400
,,	Annealed	34,700	28,500	30,800
,,	Normalised	34,700	29,800	30,800
,,	Heat-Treated	64,000	51,000	52,000
		68,000	52,000	55,000
		73,000	58,300	61,000
3½ nickel ..	Normalised	52,750	45,000	44,000
Stainless iron	,,	28,000	40,000	48,000
Pure nickel ..	As rolled	16,000	Fractured at 39,600 lb. per sq. inch after 1,323,000 cycles.	40,000
,, ..	,,	30,000	Not broken at 43,000 lb. per sq. inch after 3,245,000 cycles.	43,000
3 per cent. nickel	Normalised	31,500	30,000	46,800
Copper ..	Rolled	22,500	Fractured at 19,800 lb. per sq. inch after 1×10^8 cycles.	24,000
Phosphor bronze	,,	52,000	Fractured at 36,000 lb. per sq. inch after 608,900 cycles.	51,000
Brass ..	,,	26,000	Fractured at 27,000 lb. per sq. inch after $1{\cdot}3 \times 10^8$ cycles.	34,000
Brass ..	Annealed	9,500	Not broken after 4×10^6 cycles at 18,000 lb. per sq. inch.	18,000

value was 30,000 lb. per square inch, the elastic limit in tension being 31,500 lb. per square inch. Referring to the case of the brass the endurance limit by deflection was 34,000 lb. per square inch, but fracture occurred at 27,000 lb. per square inch after $1{\cdot}3 \times 10^8$ cycles of stress with an artificial elastic limit in tension of 26,000 lb. per square inch. This material on being annealed, gave a deflection endurance limit of 18,000 lb. per square inch, and yet did not fracture when stressed at 18,000 lb. per square inch for 4×10^6 cycles, the elastic limit in tension being 9,500 lb. per square inch.

It is felt that the results recorded are comprehensive enough to advance the conclusion that, unless the position of the elastic limit in tension be considered, this deflection method has decided limitations.

(*f*) *Conclusions.*—On the basis of these discussions, it is felt that the importance of the elastic limit in tension has been established, and that all fatigue tests must be analysed with the tensile test results as a background.

The importance to the designing engineer of the proper interpretation of the physical tests cannot be over-estimated if the development of high-speed machines during the next decade equals that which has taken place in the last one.

EXPORT TRADE TO THE UNITED STATES.—Mr. J. Joyce Broderick, the Commercial Counsellor to His Majesty's Embassy at Washington, is at present on an official visit to this country, and will be in attendance at the Department of Overseas Trade from December 8 to December 12 inclusive for the purpose of interviewing British manufacturers and merchants interested in export trade to the United States of America. Such interviews will only be given by appointment and all applications, quoting the reference 5518 T.G., should be addressed to the Comptroller-General, Department of Overseas Trade, 35, Old Queen-street, London, S.W.1.

THE ROYAL INSTITUTION.—The before-Easter lecture arrangements at the Royal Institution have just been issued. Of the lectures of engineering interest, general courses will begin on Tuesday afternoon, January 13, at 5.15, when Professor A. Fowler will commence a course of two lectures on the "Analysis of Spectra"; on succeeding Tuesdays there will be two lectures by Professor E. N. da C. Andrade on the "Evolution of the Scientific Instrument," and two by Professor A. S. Eddington on the "Internal Constitution of the Stars." On Thursday afternoons, at the same hour, beginning on January 29, Sir William Bragg will give four lectures on the "Properties and Structure of Quarts"; Dr. Leonard Hill two on the "Biological Action of Light"; and Mr. T. Thorne Baker two on "Chemical and Physical Effects of Light." Four Saturday lectures will be given by Sir Ernest Rutherford on "Counting of the Atoms." The Friday evening meetings begin on January 16 with a discourse by Sir William Bragg on the "Investigation of the Properties of Thin Films by Means of X-rays." Succeeding discourses will probably be given by Sir Ernest Rutherford and others.

10-H.P. FOUR-CYLINDER MARINE PETROL MOTOR.

CONSTRUCTED BY MESSRS. J. W. BROOKE AND CO., LIMITED, ENGINEERS, LOWESTOFT.

Fig. 1.

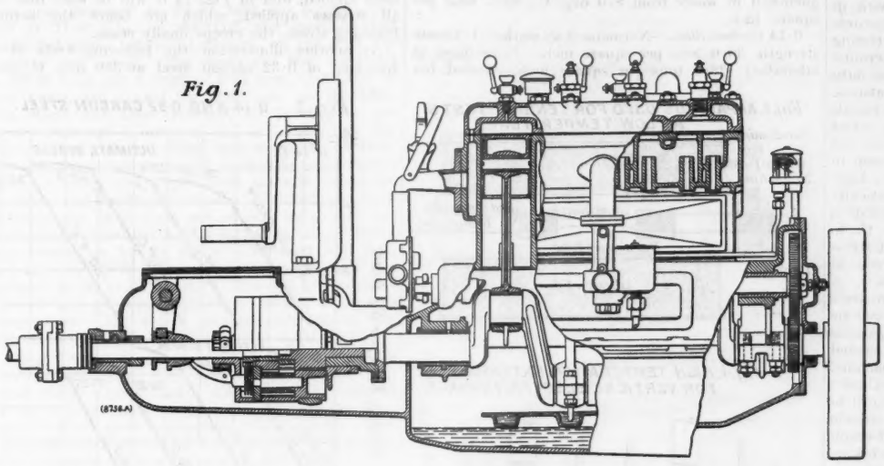
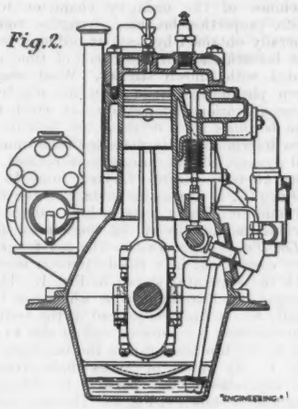


Fig. 2.



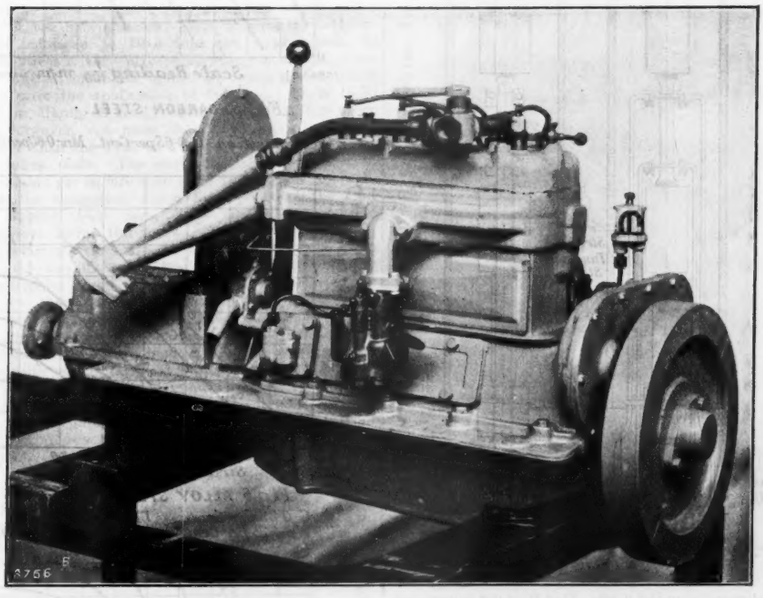


FIG. 3.

10-H.P. FOUR-CYLINDER MARINE MOTOR.

THE study of the design and construction of any type of engineering plant with a view to retaining the characteristics of reliable running and efficient action, and yet introduce such modifications as are dictated by the desire to make mass production a possibility, is always profitable, not only to the manufacturer but also to the user. Endeavours of this type deserve commendation, for the ultimate result is not only the cheapening of the product, but the consequent extension of its use and continuously increased output, which results in giving employment to a greater number of workmen. No excuse is, therefore, necessary for calling attention to a new 10 horse-power marine petrol engine put upon the market by Messrs. J. W. Brooke and Co., Limited, of Adrian Works, Lowestoft, the design of which has been considered from these standpoints. The marine motor in question, which is illustrated by Figs. 1 to 3 above, is a four-cylinder power unit of good design, in the production of which the cost have been so much reduced as to make its sale, including bronze tail-shaft and three-bladed propeller, at 100*l.* a commercial proposition. As will be seen when the components are described, great simplicity of construction has been obtained, and this, combined with manufacture on a multiple production basis in batches of 50 sets, is the means by which the economies in manufacture have been effected. It must not be taken, however, that because the design is simple little consideration has been paid to the subjects, important to the user, of low fuel consumption and reliability, for the engine at full load uses 6 pints of petrol per hour and silent, flexible and reliable working have been demonstrated.

The engine has four cylinders of $2\frac{3}{4}$-inch bore and 4-inch stroke, and it works on the four-stroke cycle. All the cylinders and the top half of the crank-case are parts of the same casting. The cylinders are bored out two at a time, and are afterwards ground to size. Valve and tappet guides in this casting and all the various holes are drilled in a multiple machine with the use of jigs. The camshaft is made of low carbon steel and is ground from the forging. After case-hardening, the cam profiles are accurately ground. The crankshaft is made from 3 per cent. nickel steel. In grooves cut in the cast-iron pistons there are accommodated four rings, three are at the top, while the other is used as a gudgeon pin retainer. The connecting rods are simple steel stampings, in which die-cast white metal bearings are provided. To keep out foreign matter the valve mechanism is enclosed by a light steel cover, which can be quickly removed for such purposes as adjusting the tappets.

For lubrication purposes a detachable pump is driven from an eccentric on the camshaft and draws its oil supply from the sump. The delivery is carried by an outside pipe through a sight feed to the timing gear from which it drains back to the troughs in the crank-case, into which dip the projections on the connecting rods to cause the splash lubrication of the general moving system. An oil limit indicator is provided on the filling pipe, which extends to a height above the level of the cylinder heads, and serves as a vent for the crank chamber. A gear-type pump driven from the end of the camshaft, circulates the cooling water, which it delivers direct into the jacket at the aft cylinder. On the starboard side of the engine there is a carburettor or paraffin vaporiser connected to an inlet manifold, which is in one piece with the cylinder casting and is jacketed by the exhaust system. On the other side there is a British-made magneto driven by a shaft from the timing wheels, which are made of steel and fibre.

The crankshaft drive is carried through to the gear box, where there is a reverse gear of the epicyclic type, the operating lever for which is placed in a very accessible position for easy handling. There are alternate steel and copper plates on the ahead clutch system, and a convenient method of adjusting the expanding pawls is provided. In this a castellated nut is used, the turning of which takes up the wear equally on all three pawls. The adjustment of the astern equipment is outside the gear box, and is easily accessible. It will be noted from the illustrations that the chain of the starting system is completely enclosed. These complete engine sets, with the standard propellers provided, have now been installed with success in many different types of motor boats, ranging from runabout launches to small cabin cruisers.

STANDARDISATION OF COLLIERY REQUISITES.—A meeting of the British Engineering Standards Association Sectional Committee on Colliery Requisites has recently been held in London under the chairmanship of Mr. Evan Williams, the President of the Mining Association of Great Britain, principally to report progress made since the inception of the work in June last. Reports, together with detailed recommendations, were presented from the six regional committees which have now been fully constituted and have held meetings. These regional committees meet at Birmingham, Cardiff, Glasgow, Manchester, Newcastle, and Sheffield. A questionnaire for light rails, which is being drafted with the assistance and co-operation of the regional committees, is to be circulated to the mines in this country to enable the Sectional Committee to obtain particulars to assist them in dealing with this subject. A report is being prepared in South Wales regarding electrical apparatus which should be simplified and will be considered by each regional committee before the proposals contained therein are submitted to the Sectional Committee; in this connection, the co-operation of the Association of Mining Electrical Engineers is expected to be helpful. Realising the importance to the mining industry of the quality of the materials used, it has been decided to set up a national sub-committee, drawing its members principally from each of the regional committees, to consider this important subject, and make recommendations as to the materials for which specifications should be put in hand. It has also been decided to set up a national sub-committee on steel arch girder supports as well as on black nuts, bolts and rivets. The question of the requirements of the mines for wire ropes was also considered, and it is understood that the fully representative British Engineering Standards Association Committee already in existence, is to give this matter early attention.

THE EFFECT OF LOW AND HIGH TEMPERATURES ON MATERIALS.*

By PROFESSOR F. C. LEA, D.Sc.

THE effect of temperature on the properties of metals is now recognised as being of the greatest importance to mechanical engineering. The tests dealt with in the paper include:—Statical tests at temperatures ranging from — 80 deg. C. to 1,000 deg. C. in testing machines of the ordinary character to determine elastic properties, breaking strengths, and other data generally obtained by tests at ordinary temperatures. The investigation of the effect of time upon metals loaded with known stresses. What may be called creep phenomena have been investigated, and the stress at various temperatures at which the creep in time becomes zero, or does not become zero, have been determined. Hardness tests determined statically and dynamically at various temperatures. Repetition tests at temperatures varying from 15 deg. C. to 800 deg. C. in a machine giving 2,000 cycles of stress per minute. These tests include ranges of stress of various magnitudes at differing mean stresses.

Low-Temperature Tests.—The low-temperature tests were carried out in a Riehle 100-ton testing machine with the apparatus shown in Fig. 1. The apparatus consists of a Duralumin tube which can be connected rigidly to the lower crosshead of the testing machine. The specimen is connected rigidly also to the cylinder and to the top crosshead of the machine, as shown in Fig. 1. By means of Amies dials arranged outside the apparatus it was possible to obtain load-strain diagrams as shown in Fig. 2. The only point in taking these diagrams was to determine as accurately as possible the limit of proportionality and the yield-stress. No attempt has been made to obtain exact values of the modulus of elasticity, although this would not be very difficult. There is very little change in the modulus with the range of temperature referred to in Fig. 2.

The changes in tensile properties as between 15 deg. C. and — 65 deg. C. are not very great; impact tests show a greater change.

TABLE I.—*Composition of "K" Steels.*

K. 1.—Hot-rolled medium carbon steel.
K. 2.—Hardened and tempered steel.
K. 3.—Nickel-chrome case-hardening steel.
K. 4.—High tensile steel.
K. 5.—High tensile steel annealed.
No. 1.—Carbon steel.
No. 2.—Carbon steel.

—	C.	Chr.	Ni.	Mn.	Si.	S.	P.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
K. 1 ..	0·65	—	—	0·80	—	—	—
K. 2 ..	0·35	1·00	1¼	—	—	—	—
K. 3 ..	0·15	0·25	4½	—	—	—	—
K. 4 ..	0·35	0·60	3½	—	—	—	—
K. 5 ..	0·35	0·60	3½	—	—	—	—
No. 1 ..	0·14	—	—	0·68	0·19	0·040	0·045
No. 2 ..	0·32	—	—	0·58	0·22	0·052	0·049

Elastic and other Properties of Certain Steels from 15 deg. C. to 500 deg. C.—The tests to be now described have been carried out in a 10-ton testing machine by Messrs. Buckton, which has hand as well as electrical power drive. For the work to be described the hand drive has proved very useful.

Extensometer.—For elastic measurements the extensometer shown in Fig. 4 was used. The gauge length is 2 inches. The bars and the adapters were made of tungsten steel. The knife-edge rockers rested in two-plate Vees. The elongation is measured on both sides of the specimen. One scale and telescope is used for both mirrors. For calibration the blocks at the lower ends of the inner bars were removed and a micrometer attached. The yield stress of the materials was measured by the extensometer and taken at the stress at which the permanent elongation is $\frac{1}{100}$ in.

In Figs. 5 and 6 are shown plotted the load strain curves for various temperatures for two steels, particulars of which are given in Table I. It will be seen that for the 0·65 per cent. C. steel a considerable change takes place in the limit of proportionality between 200 deg. C. and 300 deg. C., but the limit of proportionality given by these curves is not by any means a fixed limit, as it can be raised artificially by "overstressing" in tension.

Ultimate Strength, Yield-Stress, &c., of Various Steels.—Static tests on 0·14 and 0·32 Carbon Steels at various Temperatures.—The compositions of the steels are shown in Table I, Nos. 1 and 2. At ordinary temperatures the strength of the steel depends entirely upon the condition as delivered from the works or whether normalised after receipt. The following show results of tests at ordinary temperatures of 0·32 carbon steel and 0·14 carbon steel normalised at the laboratory after receipt.

* Paper, abridged, read before the Institution of Mechanical Engineers on Friday, December 5, 1924.

0·32 *Carbon Steel.*—Normalised at laboratory after receipt. Ultimate strength, 35·4 tons per square inch. Normalised at works, 36·4 tons per square inch. Reeled bar as delivered from the works, 41·8 tons per square inch. Specimen quenched in thick oil from 870 deg. C., 49·4 tons per square inch. Specimen quenched in water from 870 deg. C., 89·7 tons per square inch.

0·14 *Carbon Steel.*—Normalised at works. Ultimate strength, 30·6 tons per square inch. Normalised at laboratory, 28·9 tons per square inch. Reeled bar as delivered from the works, 33·4 tons per square inch. Reeled bar normalised at laboratory, 29·6 tons per square inch. Specimen quenched in water from 890 deg. C., 48·5 tons per square inch.

Fig. 1. APPARATUS USED FOR TENSILE TESTS AT LOW TEMPERATURES.

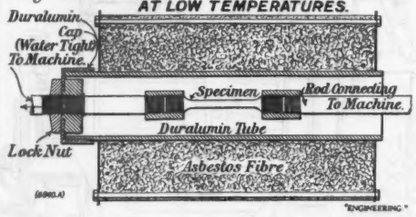
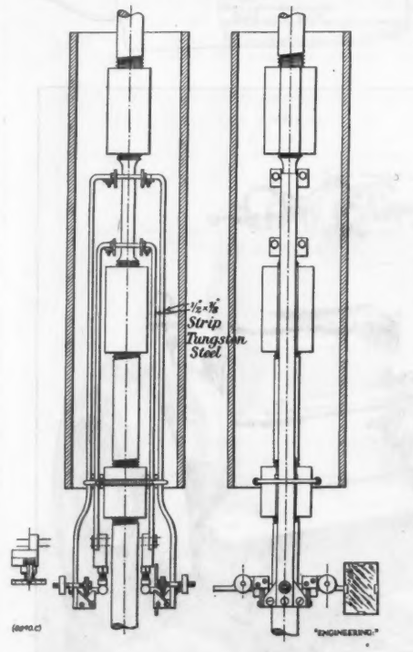


Fig. 4. HIGH TEMPERATURE EXTENSOMETER FOR VERTICAL ELECTRIC FURNACE.



Experiments on Creep.—The author puts forward the following hypothesis that at each temperature there is a particular stress below which the metal may be temporarily viscous—that is, it continues to deform under a continuously applied stress, but that with time the viscous material solidifies and the rate of creep diminishes to zero. Above this stress the material continues viscous* and with time will finally fracture. The curves drawn in Fig. 13 were obtained from a test of a mild steel specimen. The specimen was loaded in the testing machine and allowed to yield. By means of an extensometer the "creep" of the specimen was observed while loaded at 16·92 tons per square inch. After 70 minutes the creep ceased, and the creep-time curves became parallel to the axis of time. The specimen was then loaded to 17·11 tons per square inch, and after 80 minutes the creep again ceased. Other stresses were applied, and in Fig. 13 it will be seen that at all stresses applied, which are below the actual breaking stress, the creeps finally cease.

As another illustration the following tests of a specimen of 0·32 carbon steel at 350 deg. C. and of a mild steel specimen dead loaded are of interest.

* The use of the term viscous is not above criticism. For true viscosity the rate of creep under the applied stress should be uniform. This is not actually so, even in the case when the stress is sufficiently high to cause fracture ultimately.

Fig. 2. 0·14 AND 0·32 CARBON STEEL.

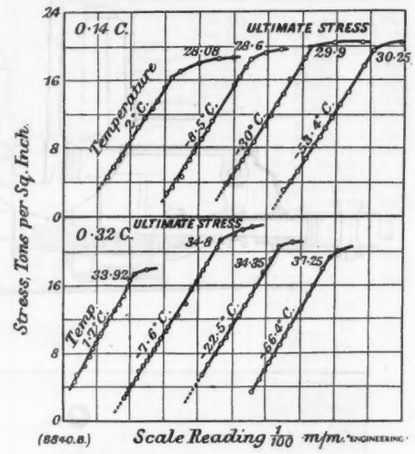


Fig. 5. CARBON STEEL.

Composition:- C-0·65 per Cent. Mn-0·80 per Cent.

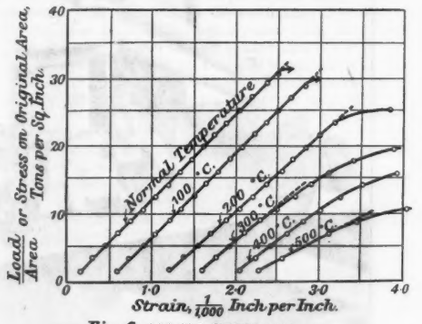
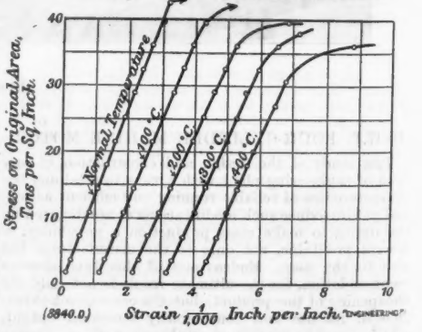


Fig. 6. ALLOY STEEL K2.

C-0·35 per Cent. Chr-1 per Cent.
Ni-1·25 per Cent. Diameter 0·375 Inch.



Tests on Specimen of 0·32 Carbon Steel at 350 deg. C.—Diameter of specimen 0·376 in. Time of commencement of test 4.34 p.m. Date, April 4. Stress* 22·5 tons per square inch. This stress and temperature remained constant until 4.30 p.m. on April 9, when creep had apparently definitely ceased. A total creep of something like 1·8 mm. had taken place in this time on a length of 4 in. The stress was then increased to 24·25 tons per square inch; by 2.23 p.m. on the 10th there was practically no creep. This indicates that

* Stress is equal to load divided by original area of the specimen.

whatever slip had taken place during the previous loading had definitely hardened the material, and that it will thus stand a higher stress without creep. The stress was now raised to 26·09 tons per square inch and up to 10.40 a.m. on April 11 the creep was 0·18 mm., but the creeping had ceased. The stress was now increased to 27·89 tons per square inch and at 11.40 a.m. on the 11th the specimen had crept 0·2 mm., but at 11.40 a.m. on the 14th the creeping had ceased. The stress was then increased to 29·66 tons and a creep of 0·20 mm. took place in four hours, but ceased by 10.40 a.m. on the 15th. The stress was then increased to 31·46 tons per square inch and a creep of 0·5 mm. occurred, but the creep had definitely ceased by 9.45 a.m. on the 16th. The stress was then increased to 33·3 tons per square inch. A creep of 1·5 mm. took place in six hours, the creep had apparently ceased. The load was then increased to 34·1 tons per square inch, and the specimen increased in length 0·6 mm. and the creeping was continuous for 1½ hours. The load was then increased to 35·02 tons per square inch, and the specimen broke in 25 minutes. This can be compared with 42 tons per square inch for static tests at this temperature. The actual breaking strength at this temperature is probably 34 tons per square inch.

Creep Test of Specimen of Mild Steel at Ordinary Temperatures.—Long time test of specimen, 0·2-in. initial diameter (dead load). All stresses are measured on the original area—that is, the area at the time when a given load is supplied. A specimen about 0·2-in. diameter was loaded by dead load on March 11 with a stress of 14 tons per square inch. In 24 hours there was no perceptible creep. An increase of the stress to 15·81 caused no perceptible creep. The area of the specimen was then diminished, and the stress increased to 19·8 tons per square inch, at which stress a very perceptible elongation took place and creep continued quite perceptibly for three hours after the application of the load. From 10.30 a.m. on March 19 to 12 noon on April 4, the creep was, however, not more than 0·02 mm., and from April 4 until the 11th no further creep at this stress had taken place. The stress was then increased to 25·82 tons per square inch until 12 noon on April 16. After the elongation which took place as the load was applied from zero, there was no perceptible elongation during 100 hours. The load was removed, the specimen reduced to 0·155-in. diameter, and then the load was increased gradually to 28·3 tons per square inch; there was no creep in two hours. The load was then increased to 29·2 tons per square inch, and a very slight creep took place in 22 hours, but the creep ceased. Gradually increasing the load to 31·09 tons per square inch in 10 minutes caused no perceptible creep until 31·09 tons per square inch was reached. For half a minute this load was held, and then a very slight creep of $\frac{1}{1000}$ mm. took place in a few seconds, followed by creeping at a rate of 0·7 mm. per second until the specimen fractured. A specimen of the same steel, 0·625-in. diameter, was broken in an ordinary testing machine; the yield-point was 19·5 tons per square inch, and the breaking strength 30·2 tons per square inch. These tests indicate very clearly that what is generally called the breaking stress at ordinary temperatures is approximately the load, divided by the original area, which will cause continuous creep, and show at least that this stress can be approached very nearly without continuous creep taking place.

The final breaking stress, as might be expected, was a little larger in the case of the specimen broken very gradually than in the specimen broken in the ordinary way. At the present time the author has a further specimen in a testing machine, which has been loaded continuously, and at gradually increasing stress, for several months. This is now carrying a load greater than that which originally would have broken the specimen.

Table IV shows the final results of other preliminary tests carried out at 600 deg. C. and 700 deg. C. on the steels indicated in the figures and details of which are given in Table I. The specimens were raised to the given temperatures, and then loaded gradually until at the given stress a very definite creep was observed. The stress was then kept constant and the elongations recorded at certain intervals.

These tests indicated that the time taken was not long enough, and that at even lower stresses the steels might probably have broken. The following test was, therefore, carried out. A specimen, K2, was heated to 525 deg. C., and then loaded with 3 tons per square inch (Fig. 16). A very slow creep took place. After three days the current was accidentally cut off. On reheating and reloading the creep ceased on the 4th day. The stress was then raised to 4 tons per square inch, but no creep at this stress occurred. The stress was then raised to 6 tons per square inch, the temperatures being maintained constant within a range of plus and minus 5 deg. C. The elongation was very small indeed, and apparently finally ceased. The stress was then raised to 7 tons per square inch. A creep of very definite magnitude now occurred, and readings were taken every two or three hours. On the 30th day the elongation was about 11 per cent., when, due to some unforeseen circumstance in the power circuit, the temperature was raised to 560 deg. C. The load was run off, the temperature adjusted, and the load again applied. The specimen broke on the thirty-fourth day with a final elongation of 34·5 per cent. and reduction of area of 53·8 per cent. The bar was naturally oxidized rather badly. The fracture was rugged and cracks were starting near to the point of fracture. With a test carried out in the ordinary way the breaking stress at 500 C. was 28·5 tons per square inch and the elongation was 22 per cent., and at 525 deg. C. the breaking strength was 25 ton per square inch. It is seen from these tests that the time effect is all important.

TABLE IV.

Temperature of Test.	Steel Mark.	Creep Stress and Breaking Stress.	Elongation.	Reduction of Area.	Time of Test.
Deg. C.		Tons per sq. in.	Per cent.	Per cent.	Hrs. min.
600	K2	7·2	38	85·5	4 23
600	K3	6·0	63	95·5	5 15
600	K4	7·2	62·5	91·8	3 20
600	K5	8·0	43	86·7	5 30
700	K3	2·27	38	92·3	10 30
700	K4	2·71	65	92·0	6 10
700	K5	3·61	55	87·8	5 10

Fig. 13. CREEP TEST ABOVE ELASTIC LIMIT MILD STEEL AT 15°C. EXTENSION-TIME RELATION.

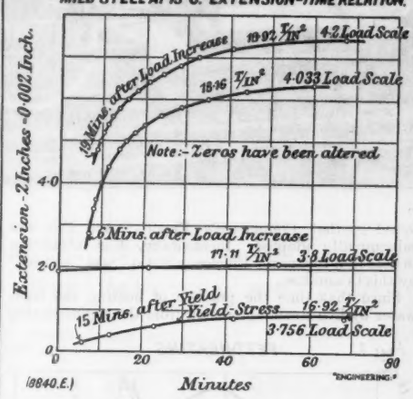


Fig. 16. TESTED AT 525 DEGS. CENT.

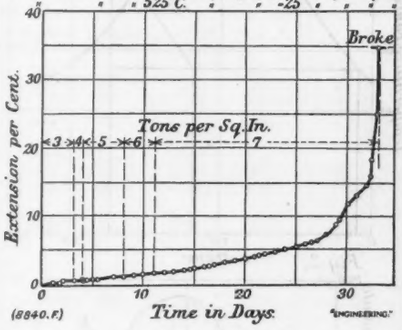


TABLE V.

Temperature of Test	Ultimate Stress.	Elongation.	Reduction of Area.	Time of Test.	First Creep.
Deg. C.	Tons per sq. in.	Per cent.	Per cent.	Hrs. min.	Tons per sq. in.
16	48·1	23	49·5	1 0	26·9†
700	2·27	88	92·3	10 30	2·27
0 to 770	5·00 (constant)	67·2	94·2	3 10	5·00*

* At a temperature of 610 deg. C.
† Limit of proportionality.

As already remarked the elongation is not always continuous and in this test it took place in spurts, followed by a partial recovery as though slipping and sticking were taking place, like a body moving on a rough inclined plane.

Tests at Constant Stress and Varying Temperatures.—A specimen of the steel K3 was loaded with 5 tons per square inch and the temperature gradually raised until at 770 deg. C., and, at the end of four hours, fracture took place. Obvious creep took place when the temperature was 610 deg. C. The elongation per cent. at fracture was 67·2 per cent., and the reduction of area 94·2 per cent. The effect of time is again illustrated in Table V.

(To be continued.)

PETROL DRIVEN RAIL CAR WITH FOUR-WHEEL DRIVE.

IN order to facilitate the maintenance of the overhead construction of electric railways and tramways it is usual to provide self-propelled vehicles which can travel rapidly to any point with men and material when the line is dead, the vehicles being designed so as to afford an elevated working platform when desired. A vehicle of this kind has recently been ordered by the Norwegian State Railways from the Four Wheel Drive Lorry Co., Limited, of Slough, and it is interesting as an example of the application to railway work of the system of drive developed by the makers for road traction. We illustrated the Four-wheel Drive lorry, and gave drawings of its transmission gear, in our issue of December 7 last year, on page 705, so that there is no need again to describe the design of the mechanism in detail. The new vehicle, the chassis of which is illustrated on the next page, is of the F.W.D. passenger type, but of shorter length and wheelbase and fitted of course, with flanged railway wheels. The wheels are 33½ in. diam. and of standard gauge. The wheelbase is 10 ft. 4 in. long, the length of the vehicle over buffers is 24 ft. 10 in.; over headstocks 21 ft. 10 in., and inside dashboards 19 ft. 8 in. Its overall width is 7 ft. 8 in. The weight of the chassis is approximately 5½ tons, and the tanks will carry 18 gallons of cooling water and 17 gallons of petrol for the engine.

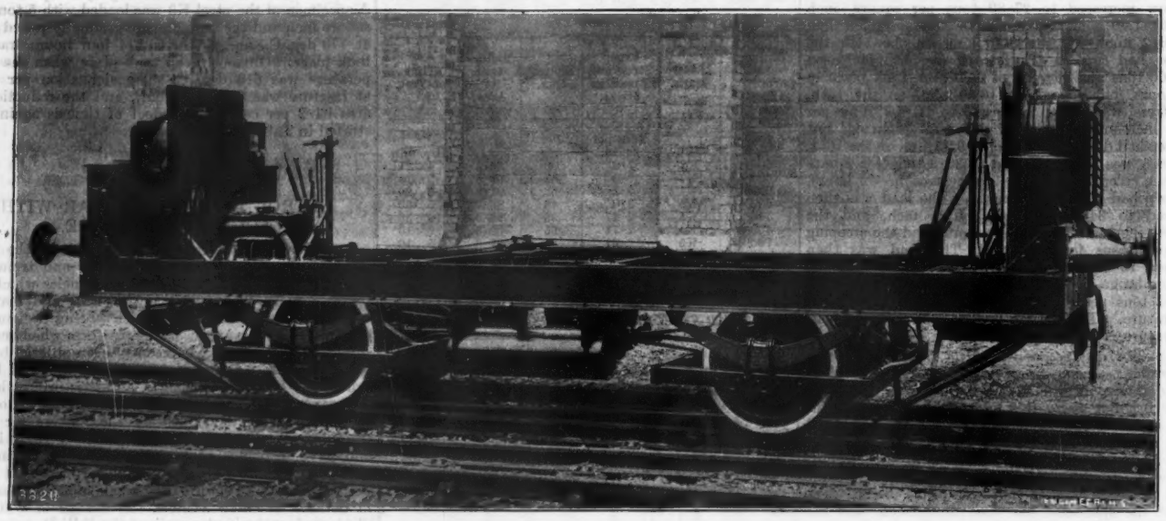
Power is furnished by a four-cylinder vertical engine of the usual lorry type, with a cylinder bore of 4¼ in., and a stroke of 5½ in. This will give 54 brake horse-power, and at normal revolutions will propel the rail-car in either direction at speeds of 5½, 7½, 15 or 30 miles per hour, according to the gear in use. The four speeds in the gear box are of the constant mesh type engaging by dogs, all gears and shafting being fitted with ball or roller bearings. All the driver's controls are duplicated, so that the vehicle can be driven equally well from either end, and care has been taken that all control movements are absolutely symmetrical. Gear changing is effected by a gate mechanism with a link and lever device which enables the gear to be changed from either end of the vehicle. To effect this a straight link is pivotted at its centre to a lever mounted on the striking-gear shaft of the gear box. The outer ends of this link are connected one to each change speed gate, and the end connected to the neutral or dead end of the car acts as a fulcrum for the link when it is operated by the driver at the other end. Reversing is effected by a separate lever acting through a similar device.

Two independent brakes are fitted. The hand-brake, of the pull-on ratchet type acts on a drum at the back of the gear box, and thus, through the transmission gear to all four wheels. A Westinghouse air brake acts directly on drums on all four of the wheels. Air for this brake is supplied by a small compressor driven by a chain from the front end of the reverse gear-box. The suction valve is controlled by the air pressure, so that when the air reservoir is full, the valve is held open, and the compressor runs idly. Two reservoirs are provided, one for the brakes and one for the whistle, delivery to the two is simultaneous, but a non-return valve is fitted in the brake reservoir, so that if the whistle reservoir is exhausted no air can be drawn from the brake reservoir, whereas the whistle reservoir will supply the brake reservoir when the pressure in the latter is low. This is arranged, of course, to ensure that the air brakes are always available. A conductor's emergency valve is provided at each end of the vehicle, by which the air brakes may be applied at reduced pressure, but cannot again be released by the conductor. When, however, the conductor's valve is shut off, the brakes are again under the control of the driver and may be released by him. A separate brake-operating cylinder is provided for each wheel, these are mounted directly on the spring carriages, and connected to the stationary part of the chassis by flexible tubes.

The frame of the rail car is of rolled steel channels, 10 in. deep by 3½ in. flange width, with buffer beams and cross members rigidly connected by means of large gusset-plates. The engine and gear-box are

PETROL-DRIVEN RAIL CAR WITH FOUR-WHEEL DRIVE.

CONSTRUCTED BY THE FOUR-WHEEL DRIVE LORRY COMPANY, LIMITED, ENGINEERS, SLOUGH.



carried on a sub-frame. The springs are of the semi-elliptic type mounted on special spring carriages resting on the axle spring seats. The springs, by this means, are transferred to the outside of the wheels, increasing the spring centres from 3 ft. 5½ in. to 6 ft. 6½ in. Large gilled-tube radiators are fitted at each end of the car. The water circulation is from the top of the engine to the top of the rear radiator, from the bottom of rear radiator to the top of the front radiator, and thence down through that radiator and through a centrifugal pump to the engine. To control the temperature of the radiator louvred shutters are fitted; these may be adjusted from the driver's seat. This is necessary as the vehicle is to be used in a cold climate and may, of course, be standing for a considerable time during repair work.

To start the engine a C.A.V. starting and lighting set is fitted, the accumulator being placed between the frames. The vehicle will haul a normal load of 40 or 50 tons, but much more than this can be handled in emergency.

THE THERMAL EFFICIENCY OF STEAM ENGINES.*

Standards of Comparison in connection with the Thermal Efficiency of Steam Engines.

By Captain H. RIALL SANKEY, C.B., C.B.E., R.E. (ret.)

Introductory Notes.—The "Heat Engine and Boiler Trials Tabulation Committee," appreciating the fact that the present standard of comparison needed development to render it applicable to re-heating and feed-heating cycles which have been adopted comparatively recently, asked the author to prepare the following short memorandum on the subject with a view to discussion at a joint meeting of the Institutions represented on the Committee.

The question of a standard of comparison for steam-engine efficiencies was first prominently brought forward by Willans in 1888, in his paper "Economy Trials of a Non-condensing Engine."† The matter was developed in Reynolds' paper, "Triple-expansion Engines and Engine Trials"‡; in Willans' paper, "Steam Engine Trials"§; and in a paper by the present author entitled "Thermal Efficiency of Steam Engines."‖

As a consequence of this, in March, 1896, The Institution of Civil Egineers appointed a Committee, under the chairmanship of Sir Alexander Kennedy, to determine a standard of comparison for steam engines. The standard proposed by the Committee was the Rankine cycle, a definition of which will be found in that Committee's Report,* and this was subsequently adopted. Incidentally, it is interesting to note that the term "Efficiency Ratio" was "coined" by this Committee.

Since that time the practice of heating the feed-water by live steam abstracted from the engine during expansion, known as "bleeding," has been developed, resulting in considerable economy, but to this case the Rankine cycle does not apply. The practice is also adopted of re-heating the steam after a partial expansion, a process which can be repeated once or more, after which the steam is expanded to the back pressure, but it would be stretching the definition to apply it to this case. Further, these feed-heating and re-heating cycles can be combined, and the question arises, can a standard of comparison be defined that will meet all cases?

Fig. 1. FEEDHEATING

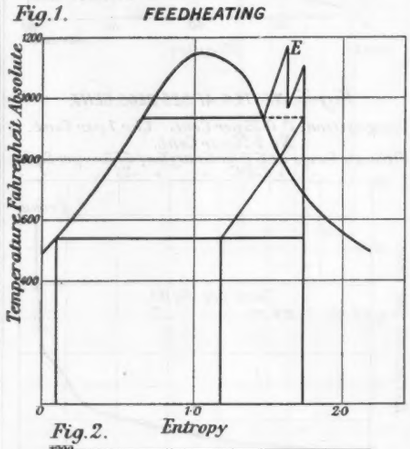
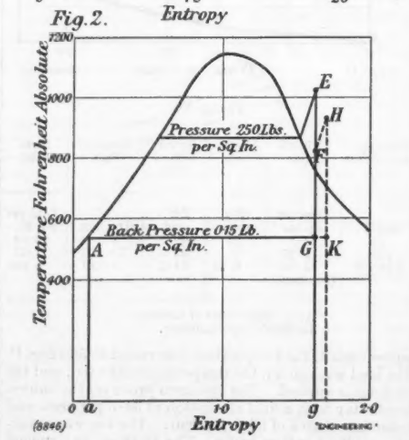


Fig. 2.



Suggested Definition of Standard.—It is submitted that if, in the definition referred to above, the sentence: "Beyond that point expansion takes place adiabatically, doing work until the pressure in the cylinder is equal to the back pressure against which the engine is working," be extended, the definition would apply to all cases. (The point referred to is the "point of cut-off" at which supply of heat from the boiler ceases, (see point *E*, Fig. 1).

The development proposed is as follows*:—"Beyond that point expansion takes place adiabatically, doing work until any desired pressure is reached, when the steam is re-heated at constant pressure to any desired temperature whence adiabatic expansion takes place; such re-heating process can be repeated as often as desired. Finally, the steam is expanded adiabatically until the temperature of saturation corresponding to the boiler pressure is met. From this point *either* adiabatic expansion continues doing work until the pressure in the cylinder is equal to the back pressure against which the engine is working *or* the steam is expanded so that a portion of the heat is transferred to the feed-water in such a manner that at every temperature the amount of heat so transferred is equal to the increase in water heat at that temperature until the pressure in the cylinder is equal to the back pressure against which the engine is working."

In practice, the following main cases occur resulting from the omission of one or more of the factors of the comprehensive definition:—

(1) Saturated steam with simple adiabatic expansion to the back pressure.

(2) Superheated steam with simple adiabatic expansion to the back pressure.

(3) Superheated steam with one or more re-heats with final adiabatic expansion to the back pressure.

(4) Saturated or superheated steam with feed-heating expansion to the back pressure.

(5) Superheated steam with one or more re-heats and final feed-heating expansion to the back pressure.

The thermal efficiency of any heat-engine is defined as the ratio of the heat utilised as work to the heat supplied, and in the case of the standard of comparison just defined these two heat quantities can be determined by formulas, but even in the simplest cases these formulas are very cumbersome and the calculations are lengthy.

For practical purposes, the thermal efficiency can be obtained approximately by the use of the Mollier chart while, if greater accuracy is desired, calculations can be made in conjunction with steam tables, and in order to ensure the correct sequence being followed a rough sketch of the $\theta\phi$ kind is advisable. This method is illustrated in the following two examples,

* Paper read at a joint meeting of various Institutions at the Institution of Civil Engineers on Thursday, December 11, 1924, at 6 p.m., in connection with Committee on Tabulating the Results of Heat Engine and Boiler Trials.

† Minutes of Proceedings Inst. C.E., vol. xciii, page 128, and vol. xcvi, page 230.

‡ *Ibid.*, vol. xcix, page 152.

§ *Ibid.*, vol. cxiv, page 2.

‖ *Ibid.*, vol. cxxv, page 182.

* *Ibid.*, vol. cxxxiv, page 287.

* The full definition of the Rankine cycle as amended to suit modern conditions will be found at the end of these introductory notes.

in which Callendar's Fahrenheit steam tables have been used, the $\theta\phi$ sketches being shown in Fig. 2.

Conditions. EXAMPLE I.

Admission pressure ... 250 lb. per sq. in. abs.
Admission superheat ... 160 deg. F.
Back pressure ... ... 0·5 lb. abs.

The $\phi\theta$ sketch for this example is shown by the full lines in Fig. 2.

From the tables it is found that the total heat at the point E is 1302·1 B.Th.U. per lb., and that the water-heat at A is 47·4 B.Th.U. per lb. Hence the heat supplied per lb. is 1302·1 − 47·4 = 1254·7 B.Th.U.

The heat rejected is represented by the area AG*ga*. From the tables the entropy at G is 1·6348 and at A, 0·0920; hence the length AG is 1·6348 − 0·0920 = 1·5428.

The absolute temperature at A at 0·5 lb. per square inch absolute pressure is 539·1 deg. F.; hence the area AG*ga*, *i.e.*, the heat rejected, is 1·5428 × 539·1 = 831·9 B.Th.U.

Consequently the heat utilised is 1254·7 − 831·6 = 423·1 B.Th.U. Finally, the thermal efficiency is—

$$\frac{423\cdot1}{1254\cdot1} = 33\cdot70 \text{ per cent.}$$

EXAMPLE II.

Conditions.—These are the same as in the first example, with the addition that the steam is expanded to 100 lb. abs. pressure, and is then re-heated to 100 deg. F., after which it is expanded to a back pressure of 0·5 lb. per square inch abs. This addition is shown by the dotted lines in Fig. 2.

The first expansion is along the adiabatic EF and F is at 100 lb. abs. pressure. The temperature at F has to be found, and this can be done by the formula:

$$T_F = T_E \left(\frac{P_F}{P_E}\right)^{3/13} = 1020\cdot8 \left(\frac{100}{250}\right)^{3/13} = 826\cdot2.$$

The saturated temperature at 100 lb. abs. being 787·3 deg. F., the superheat at F is 826·2 − 787·3 = 38·9 deg. F.

The steam is now re-heated along FH and the temperature increased 100 deg. F. The heat required for this process can be found in interpolation from the steam tables, thus at 38·9 deg. superheat, it is 1212·79 and at 138·9 deg. superheat, it is 1265·83. Hence the heat required to re-heat along FH is 1265·83 − 1212·79 = 53·0 B.Th.U.

The next step is to find the heat rejected, and for this purpose the entropy GK is found by interpolation from the steam tables to be 0·0606. As in the previous example, the entropy at G is 1·6348, and at A 0·0920; hence, the length AK is 1·6348 + 0·0606 − 0·0920 = 1·6034, and the heat rejected is 1·6034 × 539·1 = 864·39 B.Th.U.

The heat supplied up to the point E is the total heat at E, less the water heat at A, or 1302·1 − 47·4 = 1254·7 B.Th.U., to which must be added the heat for re-heating from F to H, namely, 53·0 B.Th.U. as found above. Hence the heat supplied is 1307·7 B.Th.U., and the heat utilized is 443·3 B.Th.U., and the thermal efficiency is $\frac{443\cdot3}{1307\cdot7} = 33\cdot90$ per cent.

A tabular method of making these calculation is given in Appendix I.

A number of cases have been worked out and are collected together in Table I. The steam data have been taken from the enlarged Callendar Steam Tables (Fahrenheit units).*

In the Benson cycle (item 28) steam is generated at the critical temperature (706 deg. F.) at a pressure of 3,200 lb. abs. The steam is then expanded by throttling to a pressure of 1,500 lb. abs., after which it is re-heated to a temperature of 800 deg. F. Adiabatic expansion then takes place to the back pressure (0·5 lb.) in the case worked out.

For comparison the thermal efficiency of a gas-engine and of an oil-engine have been worked out.

Column 3 gives the highest temperature in each case, and Column 7 gives the Carnot cycle working between this temperature and the exhaust temperature (539·1 deg. F. abs. in the case of the condensing engines).

It will be noted from Column 8 that the ratio of the thermal efficiency of the standard to that of the Carnot cycle varies to a large extent, proving (if proof were necessary) that the Carnot cycle is unsuitable as a standard of comparison.

In Table II (page 820), some cases given in Table I (in which Callendar's steam tables were used) have been repeated and compared with the same cases worked out, using Marks and Davis' and Goodenough's tables. It will be seen that the disparities in heat supply and heat rejected at the lower pressures are small, but increase as the pressure increases, reaching in one case as much as 4·6 per cent. for the heat supplied and 6·2 per cent. for heat utilised. The disparities in the thermal efficiencies are, however, small, the greatest being about 0·7 per cent.

Experiments to determine steam constants more accurately are in progress in the United States of America, under the direction of Dr. Davis, and under the auspices of the American Society of Mechanical Engineers, while in this country Professor Callendar and the B.E.A.M.A. are similarly engaged, and are in correspondence with the America investigators. Subject to any fresh values that may emerge from these experiments, it would appear that the thermal efficiency of the standard of comparison can be obtained with sufficient practical accuracy by the use of any of the three steam tables compared above.

The definition of the Rankine cycle as adopted by a previous committee, but amended to accord with the modern developments referred to in this paper, is given in full below:—

It is assumed that all the component parts of the steam plant are perfect, and that there are no losses due to initial condensation, leakage, radiation, or conduction, and that there is no clearance in the cylinder. The feed-water required is taken into the boiler at the exhaust temperature, and its temperature is gradually raised until that corresponding to saturated steam is reached. Steam is then formed at constant pressure until dry saturated steam is produced, after which, if the steam is to be superheated, heat is added at constant pressure and at increasing temperature, until the required temperature of superheat is reached. The steam is introduced into the cylinder at constant pressure, displacing the piston, and performing external work equal to the absolute pressure multiplied by the volume swept through by the piston up to the point of cut-off.

Beyond that point expansion takes place adiabatically, doing work until any desired pressure is reached, when the steam is re-heated at constant pressure to any desired temperature whence adiabatic expansion takes place; such re-heating process can be repeated as often as desired. Finally, the steam is expanded adiabatically until the temperature of saturation corresponding to the boiler pressure is met. From this point either adiabatic expansion continues doing work until the pressure in the cylinder is equal to the back pressure against which the engine is working, or the steam is expanded so that a portion of the heat is transferred to the feed-water in such a manner that at every temperature the amount of heat so transferred is equal to the increase in water-heat at that temperature until the pressure in the cylinder is equal to the back pressure against which the engine is working. The steam

TABLE I.

1. Item No.	2. Description of Cycle.	3. Maximum Temperature Deg. Fahr.	4 Heat Supplied	5. Heat Utilized.	6. Thermal Efficiency of Standard.	7. Thermal Efficiency of Carnot Cycle.	8. Ratio—T.E. Standard Cycle. / T.E. Carnot Cycle.
			B.Th.U. per Lb.		Per cent.	Per cent.	Per cent.
	NON-CONDENSING. Admission pressure 120 lb. per sq. in. abs. Saturation temperature 341·1° F. Back pressure 15 lbs. per sq. in. abs. Back pressure temperature 213·0° F.						
1	Saturated	341·1	1014·1	152·8	15·07	16·00	94·18
2	Superheated 100° F.	441·1	1069·1	164·2	15·36	25·32	60·65
	CONDENSING. Admission pressure 120 lbs. per sq. in. abs. Saturation temperature 341·1° F. Back pressure 0·5 lbs. per sq. in. abs. Back pressure temperature 79·5° F.						
3	Saturated	341·1	1147·7	358·2	29·47	32·67	90·19
4	Superheated 100° F.	441·1	1202·7	358·2	29·78	40·15	74·19
5	Superheated 100° F. Expanded to 100° F. temperature drop. Reheated 100° F.	441·1	1254·8	377·1	30·05	40·15	74·84
6	Superheated 100° F. Expanded to 100° F. temperature drop. Reheated 100° F. Expanded to 100° temperature drop. Reheated 100° F.	441·1	1305·2	394·1	30·19	40·15	75·19
7	Saturated and feedheating	341·1	882·8	288·5	32·67	32·67	100·0
8	Superheated 100° F. and feedheating	441·1	937·8	308·5	32·93	40·15	82·21
9	Superheated 100° F. Expanded to 100° F. temperature drop. Reheated 100° F. and feedheating.	441·1	989·9	327·5	33·08	40·15	82·39
10	Superheated to 700° F. total temperature	700·0	1334·9	420·6	31·51	53·51	58·89
	CONDENSING. Admission pressure 250 lbs. per sq. in. abs. Saturation temperature 401·2° F. Back pressure 0·5 lb. per sq. in. abs. Back pressure temperature 79·5° F.						
11	Saturated	401·2	1162·3	383·7	33·01	37·37	88·33
12	Superheated 160° F.	561·2	1254·7	422·8	33·70	47·19	71·46
13	Superheated 160° F. Expanded to 100 lbs. abs. pressure.	561·2	1307·7	443·3	33·90	47·19	71·84
14	Superheated 160° F. Expanded to 100 lbs. abs. pressure. Reheated 100° F. Expanded to 50 lbs. abs. pressure. Reheated 100° F.	561·2	1366·2	464·1	33·97	47·19	71·99
15	Saturated and feedheating	401·2	833·4	311·4	37·37	37·37	100·0
16	Superheated 160° F. and feedheating	561·2	925·8	350·7	37·88	47·19	80·27
17	Superheated to 700° F. total temperature	700·0	1327·7	462·1	34·80	53·51	65·04
	CONDENSING. Admission pressure 500 lbs. per sq. abs. Saturation temperature 468·6° F. Back pressure 0·5 lb. per sq. in. abs. Back pressure temperature 79·5° F.						
18	Saturated	468·6	1174·8	425·9	36·25	41·91	86·47
19	Superheated 240° F.	708·6	1320·0	495·8	37·56	53·85	69·75
20	Superheated 240° F. Expanded to 240° F. temperature drop. Reheated 240° F.	708·6	1445·9	556·5	38·49	53·85	71·48
21	Superheated 240° F. Expanded to 240° F. temperature drop. Reheated 240° F. Expanded to 240° F. temperature drop. Reheated 240° F.	708·6	1564·6	613·8	39·23	53·85	72·85
22	Saturated and feedheating	468·6	771·0	323·2	41·91	41·91	100·0
23	Superheated 240° F. and feedheating	708·6	916·2	393·1	42·91	53·85	79·68
24	Superheated 240° F. Expanded to 240° F. temperature drop. Reheated 240° F. and feedheating.	708·6	1042·1	453·9	43·56	53·85	80·89
25	Superheating 240° F. Expanded to 240° F. temperature drop. Reheated 240° F. Expanded to saturation and feedheating.	708·6	1207·2	515·3	42·69	53·85	79·28
	MISCELLANEOUS.						
26	Admission pressure 700 lbs. per sq. in abs. Admission temperature 700° F. Back pressure 0·5 lb. per sq. in. abs. Simple expansion to back pressure.	700·0	1305·0	506·7	38·83	53·51	72·57
27	Admission pressure 1,200 lbs. per sq. in. abs. Saturated. Simple expansion to back pressure 0·5 lb. per sq. in. abs.	569·7	1184·8	475·0	40·09	47·57	84·28
28	Benson cycle—Initial pressure 3,200 lbs. per sq. in. Expanded by throttling to 1,500 lbs. per sq. in., then superheated to 800° F.—then simple expansion to back pressure of 0·5 lb. per sq. in. abs.	800·0	1331·0	563·6	42·34	57·20	74·03
29	Gas-engine. Compression ratio 5·5	2,700	17,300	6,830	39·5	83·56	47·2
30	Oil-engine. Compression ratio 12·0	3,000	19,000	10,000	52·6	84·97	61·9

* Published by Edward Arnold (1924).

is then completely exhausted from the cylinder at constant pressure corresponding with the lower limit of temperature, work being done on the steam by the engine during exhaust, equal to the absolute back pressure multiplied by the total volume swept through by the piston. The steam is thus removed from the cylinder and the cycle is complete.

APPENDIX I.

TABULATION FOR CALCULATING THE THERMAL EFFICIENCY OF A STANDARD STEAM ENGINE OF COMPARISON.

EXAMPLE 1.

Conditions.

(NOTE.—The letters refer to the $\theta\phi$ sketch, Fig. 2.)

Admission at point E. Pressure, 250 lb. per square inch abs. Temperature, 160 deg. F. superheat.

Exhaust at point G. Pressure, 0·5 lb. per square inch abs.

Item No.	Particulars.	How Obtained or Calculated.	Result.
1	Entropy at G ..	From steam tables ..	1·6348
2	Entropy at A ..	From steam tables ..	0·0920
3	Difference of entropy AG	Item (1) — Item (2)	1·5428
4	Temperature at G ..	From steam tables ..	539·1
5	Heat rejected ..	Item (3) × Item (4)	831·9
6	Total heat at E ..	From steam tables ..	1,302·1
7	Water heat at A ..	From steam tables ..	47·4
8	Heat supplied ..	Item (6) — Item (7)	1,254·7
9	Heat utilised ..	Item (8) — Item (5)	422·8
10	Thermal efficiency ..	Item (9) ÷ Item (8)	33·7

EXAMPLE 2.

Conditions.

(NOTE.—The letters refer to the $\theta\phi$ sketch, Fig. 2.)

Admission at point E. Pressure, 250 lb. per square inch abs. Temperature, 160 deg. F. superheat.

Reheating expansion to 100 lb. per square inch to point F. Superheating 100 deg. F. to point H.

Exhaust at point K. Pressure, 0·5 lb. per square inch.

Item No.	Particulars.	How Obtained or Calculated.	Result.
1R	Abs. temp. at E ..	From steam tables ..	1,020·8
2R	Abs. pressure at F ..	From conditions ..	100·0
3R	Abs. temp. at F ..	From $T_F = T_E \left(\frac{P_F}{P_E}\right)^{3/13}$	826·2
4R	Abs. saturated temp. corresponding to pressure at F	From steam tables ..	787·3
5R	Superheat at F ..	Item (3R)—Item (4R)	38·9
6R	Heat required to superheat from F to H	From steam tables ..	53·0
7R*	Difference of entropy GK	From steam tables ..	0·0606
1	Entropy at K ..	Entropy at G from steam tables + Item (7R)	1·6954
2	Entropy at A ..	From steam tables ..	0·0920
3	Difference of entropy AK	Item (1) — Item (2)	1·6034
4	Temp. at G	From steam tables ..	539·1
5	Heat rejected ..	Item (3) × Item (4)	864·4
6	Total heat at E ..	From steam tables ..	1,302·1
7	Water heat at A ..	From steam tables ..	47·4
8	Heat supplied ..	Item (6) — Item (7) + Item (6R)	1,307·7
9	Heat utilised ..	Item (8) — Item (5)	443·3
10	Thermal efficiency ..	Item (9) ÷ Item (8)	33·9

* Items (1R) to (7R) to be repeated for each re-heat and the results to be taken account of in Items (1) and (8).

CATALOGUES.

Electric Switches.—The Electric Construction Company Limited, Wolverhampton, have sent us a specification and priced list of their press-button switches.

Electric-Light Fittings.—A priced catalogue of several types of lanterns for gas-filled electric lamps is to hand from the Foster Engineering Company, Limited, Wimbledon, London, S.W.

Belting.—Messrs. William Walker and Sons, Limited, Bolton, have sent us a priced catalogue of machinery of belting in leather, cotton, hair, balata and other materials. Much useful information has been embodied in the text of the catalogue.

Switchgear.—An interesting publication, of 64 pages, 4to, compiled by Messrs. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, consists entirely of reprints of articles from the technical Press dealing with their switchgear. Full illustrations accompany the articles.

Air Compressors.—The catalogue of air compressors issued by Messrs. Robey and Co., Limited, Lincoln, deals very exhaustively with both vertical and horizontal types in a wide range of capacities. It also contains a good selection of useful technical tables relevant to the subject.

Transformers.—The English Electric Company, Limited Queen's House, Kingsway, London, W.C., have issued a new edition of their catalogue of transformers for single and three-phase systems of the usual frequencies. Several types are illustrated, including those suitable for outdoor and mining service.

Valves.—The Steam Fittings Company Limited, West Drayton, Middlesex, have issued catalogues of two valves: one a combined stop and pipe-isolating valve for boilers, and the other a flow-meter valve with recorder suitable for steam, water, air or gas. A leaflet on steam economy has also come to hand.

Foundry Supplies.—A catalogue of oils, plumbago and fluxes for use in the processes of casting iron, brass, aluminium, &c., has been issued by Messrs. Beecroft and Partners, Limited, St. Peter's-close, Sheffield, with useful notes on the practical advantages of such preparations.

Electrical Fittings.—A new edition of their general descriptive catalogue for contractors has been issued by British Insulated and Helsby Cables, Limited, Prescot, Lancs. This catalogue is very complete within its range and covers not only important material, but also the small accessories which the contractor must have to complete the work.

Well Sinking.—A recent issue of the technical periodical published by Messrs. Sulzer Brothers (of Switzerland), whose London address is 31, Bedford-square, W.C., gives a very full account of the well-boring operations at the Somerford station of the South Staffordshire Waterworks Company for which Messrs. Sulzer provided the engines for the main pumps and auxiliary plant.

Fans, Blowers, &c.—From the James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C. 4, we have received a general catalogue of their specialties, containing sections devoted to volume fans, air-blowing and exhausting fans, smiths' hearths, gas-blowing and exhausting fans, hot-water supply boilers, rotary air or gas compressors, high-pressure gas fittings, and soldering and welding outfits.

Engine Indicators.—A description of the "Farnboro" electrical indicator, which is suitable for all types of engines at all speeds, including aero engines in flight, has come to hand from Messrs. Dobbie, McInnes and Clyde, Limited, 57, Bothwell-street, Glasgow. This catalogue, which contains prints of actual diagrams, will be found of considerable interest to engineers. Other catalogues received from the firm describe the Hopkinson optical indicator and several other indicators which they manufacture.

Pulverised Coal.—The Fuller system of firing with pulverised coal, which has had considerable success in the United States, is the subject of a special catalogue issued by Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C. 4, who have acquired the sole licence for making the machinery and apparatus. The catalogue describes the machinery by which the coal is prepared, by crushing, pulverising, cleaning and drying and the magnetic separator for removing iron scrap. The burner, feed pipes, pumps and fans are also described, and much useful technical information is given.

Electrical Plant.—Four new catalogues have come to hand from the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. These deal with induction regulators for one, two and three-phase circuits up to 15,000 volts, with hand or motor control or full-automatic control; large vertical induction motors of the squirrel-cage and slip-ring types, ranging from 50 h.p. to 1,000 h.p. and up to 11,000 volts; and horizontal and vertical alternators designed for driving by hydraulic turbines. All these catalogues are fully descriptive with ample illustrations and much tehnical information.

Textile Machinery.—A catalogue of exceptional interest, describing all the necessary machinery for cotton manufacture subsequent to weaving, has reached us from Messrs. Mather and Platt, Limited, Manchester. Successive sections deal with the machines and apparatus for singeing, brushing, bleaching, boiling, electrolysing mercerising, drying, printing, ageing, soaping and dyeing and also with machines for mangling, starching, calendering, stentering, weft straightening, damping, beetling, &c. In addition to illustrations and short descriptions of the machines, under these headings, the catalogue contains a list of other publications dealing more elaborately with each type of machine.

THE THERMAL EFFICIENCY OF STEAM ENGINES.

TABLE II.

1	2		3	4	5	6
Item No.	Description of Cycle.		Maximum Temperature deg. F.	Heat Supplied.	Heat Utilised.	Thermal Efficiency of Standard Cycle.
				B.Th.U. per Lb.		Per Cent.
	CONDENSING. Admission pressure 120 lbs. per square inch abs. Back pressure 0·5 lb. per square inch abs.					
1	Saturated	Callendar	341·1	1147·7	338·2	29·47
2		Marks and Davis	341·3	1141·9	335·8	29·41
3		Goodenough	341·3	1143·8	336·7	29·44
4	Superheated 100° F.	Callendar	441·1	1202·7	358·2	29·78
5		Marks and Davis	441·3	1196·4	355·6	29·72
6		Goodenough	441·3	1199·1	357·0	29·77
	CONDENSING. Admission pressure 250 lb. per square inch. Back pressure 0·5 lb. per square inch.					
7	Saturated	Callendar	401·2	1162·3	383·7	33·01
8		Marks and Davis	401·0	1153·0	379·9	32·93
9		Goodenough	401·1	1153·0	380·2	32·97
10	Superheated 160° F.	Callendar	561·2	1254·7	423·1	33·70
11		Marks and Davis	561·0	1246·1	418·8	33·61
12		Goodenough	561·1	1257·0	429·3	34·15
13	Superheated 160° F.	Callendar	561·2	1307·7	443·3	33·90
14	Expanded to 100 lb. pressure	Marks and Davis	561·0	1297·4	438·5	33·90
15	Reheated 100° F.	Goodenough	561·1	1301·5	440·7	33·86
	CONDENSING. Admission pressure 500 lb. per square inch. Back pressure 0·5 lb. per square inch.					
16	Saturated	Callendar	468·6	1174·8	425·9	36·25
17		Marks and Davis	467·3	1162·3	419·7	36·11
18		Goodenough	467·2	1154·2	416·7	36·11
19	Superheated 240° F.	Callendar	708·6	1320·0	495·8	37·56
20		Marks and Davis	707·3	1309·0	488·0	37·28
21		Goodenough	707·2	1312·3	492·5	37·53
22	Superheated 240° F.	Callendar	708·6	1445·9	556·5	38·49
23	Expanded to 240° F. drop	Marks and Davis	707·3	1428·8	546·1	38·22
24	Reheated 240° F.	Goodenough	707·2	1440·0	553·6	38·44
	CONDENSING. Back pressure 0·5 lb. per square inch.					
25	Admission pressure 700 lb. per square inch.	Callendar	700·0	1305·0	506·7	38·83
26	Temperature 700° F.	Goodenough	700·0	1293·4	501·3	38·76
27	Admission pressure 1,200 lb. per square inch	Callendar	569·7	1184·8	475·0	40·09
28	Saturated	Goodenough	567·7	1132·1	447·5	39·53

LOSSES OF MERCHANT SHIPPING.—According to statistics just issued by Lloyd's Register of Shipping, the world's losses of merchant shipping during the quarter ended June 30 last, amounted to 116,055 gross tons, comprised in 80 vessels. Great Britain and Ireland lost 14 ships, making 29,988 tons, during the period, but the latter figure is only 0·16 per cent. of the total tonnage owned in this country. In the case of the United States, the losses amounted to 14,481 tons (12 ships), the proportion of the total American tonnage lost being a little less than that for Great Britain, viz., 0·11 per cent. Japan lost 0·28 per cent. of her merchant tonnage during the quarter under review, the losses including seven vessels with an aggregate tonnage of 10,719. For Italy the losses amounted to 10,294 tons, or 0·36 of the total tonnage, and the corresponding figures for France and Germany were 8,152 tons (0·23 per cent.) and 6,795 (also 0·23 per cent.). In proportion, the heaviest losses during the quarter were sustained by the British Dominions, the 13 ships making 17,493 lost by them, amounting to 0·63 of the total Dominion tonnage. The above-mentioned figures include steamers, motor ships, and sailing vessels of 100 gross tons and upwards, but the totals exclude cases of breaking up, condemnation, &c., which are not known to be consequent upon stress of weather, &c. If such cases are included, the total losses for the whole world amount to 404,128 tons comprised in 198 vessels.

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